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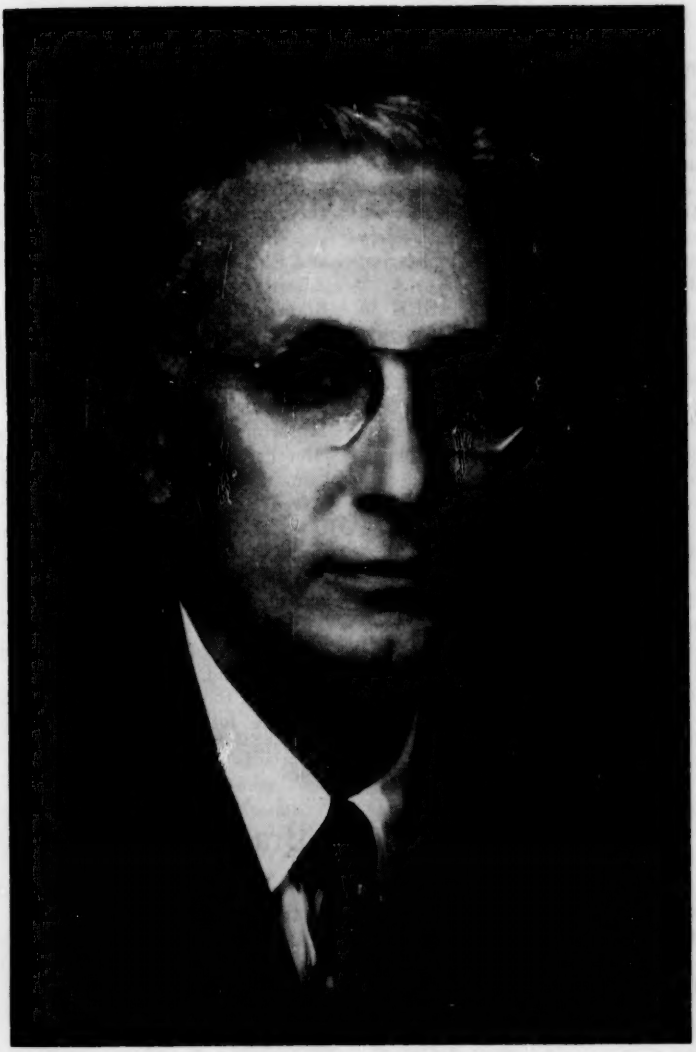

L. E. GRINTER, PRESIDENT

L. E. Grinter, President, A.S.E.E., 1953-54

President Grinter is well known to all ASEE members for his constructive and energetic activities which have led to significant milestones in the Society's progress. Among his contributions must be included the very effective work as Chairman of the Committee on the Improvement of Engineering Teaching, which brought into active participation over 1,000 members of ASEE throughout

the country and which culminated in a report of which over 10,000 copies have been sold. He was also Chairman of the Committee which prepared the "Manual of Graduate Study" and also of a subsequent committee which rewrote the Manual. During the past year, he has served as Chairman of the important Society Committee on Evaluation of Engineering Education.

As Vice President of the ASEE in 1950–52, he was an effective and inspiring leader in Society activities. Dr. Grinter has long been active in Society affairs, having helped to organize the Texas Section of ASEE, as well as the Civil Engineering Division. He was also responsible for arranging the *Civil Engineering Bulletin* as a quarterly publication with permanent financial sponsorship. Dr. Grinter was Chairman of the Committee on Civil Engineering Library that published the first check list of one thousand important books and served as a member of the General Council of the ASEE from 1936–1938 and 1948–50.

Dr. Grinter has served as a consultant to the War Manpower Commission, the Civil Defense Administration, the National Science Foundation, the Weapons Test Center, Elgin Air Force Base, the Board of Southern Regional Education and supervised revision of the section on enginering and metallurgy in the Encyclopaedia Britannica.

Our new President hails from Kansas City, Missouri. He received his B.S. from the University of Kansas, and his M.S. and Ph.D. from the University of Illinois. After two years as an engineer for the Standard Oil Company, he entered the educational field as a Professor of Civil Engineering at Texas A. & M. College. Beginning in 1937 he served as Dean of the Graduate School and Head of the Department of Civil Engineering, and later as Vice President of Armour Institute of Technology. From 1940–46 he served as Vice-President and Graduate Dean at Illinois Institute of Technology. He is now Dean of the Graduate School and Director of Research at the University of Florida.

Dr. Grinter has written many technical and educational articles in various publications and has written several books, largely in the field of structural engineering, the latest of which, "Engineering Mechanics," was published in August, 1953.

Sections and Branches

The **Pacific Northwest Section** Annual Meeting was held on the campus of the State College of Washington, April 24 and 25. The theme "Adequacy and Standards of Engineering Education" was discussed from the the standpoint of the effects of entrance requirements, accreditation, state licensing, operational funds, humanistic-social studies, and requirements of industry. The annual banquet was featured by President W. R. Woolrich speaking on "Our Responsibility to Up-Grade the Engineering Profession." In addition, the general program included the reading of the Section's winning paper in the YET contest and a report on the recent meeting of the National Committee on Evaluation of Engineering Education. April 25 was also the date for the Section's annual ECRC session.

Attendance was high and included members from Oregon State College, University of Washington, University of Idaho, Montana State College, Montana School of Mines, Gonzaga University, Idaho Junior College, General Electric Co., Boeing Airplane Co., and the State College of Washington.

The following officers were unanimously elected: Chairman, L. E. Slegel; Vice Chairman, J. W. Smith; Secretary, T. J. McClellan. E. R. Wilcox was elected Section Representative to the General Council to fill the vacancy occasioned by the passing of C. A. Mockmore.

1953-54 A Year of Evaluation

By L. E. GRINTER

President of ASEE, Dean of the Graduate School and Director of Research, University of Florida

At least once in each decade the program of undergraduate engineering education should be reviewed, evaluated, and the wheels of revision set into motion. The last concerted effort in this direction was taken nearly a decade ago when the report on Engineering Education after the War was published by the Hammond Committee. Ten years slip by so quickly that we find it difficult to realize how many things that are commonplace in engineering today were almost unkonwn in 1944. Rocket flight, jet engines, nuclear power, fluorocarbons, new commercial metals, new plastics, silicones, new fabrics, television, transistors, prestressed concrete structures, and guided missiles are developments of the past ten years. Engineering education, even if it had been thoroughly revised and brought up to date in 1944, would have suffered unavoidable dislocations from these revolutionary engineering developments.

The effect of advancements sometimes appears clearer when we look forward rather than backward. If we should do our best to bring undergraduate engineering education into adjustment with the known demands of scientific and technological advances in 1954, it is quite clear that the adjustment would be out of focus a decade later. In fact, the progress in science and engineering is so rapid that we should no longer expect to stabilize our curricula for even a decade ahead. This, however, does not relieve us of the responsibility for doing everything possible to train the leaders of the engineering profession for ten, twenty or more years in the future. Such leaders in 1964 or 1974 must be at no loss to interpret, use and themselves contribute to the development of the fields of enginering science as effectively as the engineering leaders of the nineteen twenties and nineteen thirties contributed to the development of engineering art.

The fact that we see ahead no probable plateau upon which science and engineering development can rest in its upward climb leads to the conviction that more opportunity for change and more experimentation are vital in engineering education. Too often an evaluation of a given undergraduate curriculum has proceeded on the basis of a comparison with the average course requirements in a number of other institutions. In fact, the program of accreditation has been criticized, and perhaps justifiably, for encouraging such standardization at the level of mediocrity. The weakness of all accreditation based upon minimum standards is that such minima are likely to be accepted by many individuals and institutions as representing a desired norm.

Instead of an attempt to approach the average of other educational programs by the process of evaluation we should encourage each institution to determine where and how it can produce a result of distinction. If the dean of engineering responds alike to the requests of all departments and divides the resources of the college as equitably as possible between all activities on a numerical basis, the final result is almost certain to be the achievement of mediocrity. Distinction cannot be achieved everywhere; hence the achievement of distinction in any one ac-

tivity must ordinarily mean that resources are not being divided on a numerically equitable basis. There is another viewpoint, however, of equity. If quality of achievement can be attained in a given activity, and if quality as distinct from quantity is to be recognized as having a special value to the university, additional support for this meritorious activity is fully justified. By acceptance of this philosophy an institution will develop peaks of excellence from which its influence will grow beyond its immediate locality.

If each of our colleges of engineering could set aside a small portion of its overall budget for the support of one or two distinctive programs of undergraduate and possibly graduate education, a spirit of experimentation would soon be established in place of the rather standardized or routine approach that characterizes too much of present engineering education. When the rush of veterans was at its height there was an adequate excuse for avoiding undergraduate experimentation; a smooth routine operation is always the essence of good mass production. However, the development of peaks of excellence in education will never be achieved without experimentation. Hence, an overemphasis upon organization can conflict with the objective of distinction.

A new rush of undergraduate students is due to overload our facilities and staffs in engineering education near the end of the present decade. Then again a premium may have to be placed upon mass production and the opportunities for experimentation will be reduced. Following the present *Year of Evaluation* freedom will exist for a few years of educational experimentation. It, therefore, seems probable that the next five years will be a critical period in the long-term history of engineering education.

Let us make every effort in the years immediately ahead to find workable solutions to two great problems that face us:

(1) How can we produce the necessary engineering scientists and specialists, who need intensive undergraduate work in mathematics, chemistry, physics and the many fields of engineering science, without interfering with the flow of general professional engineers that have served past generations so effectively and are still fully adequate for useful service in stabilized fields of highly applied technology, for service in production, operation, construction or maintenance, or for association with another field such as business, management, sales, law, real estate or agriculture?

(2) How can we stimulate the creative capacity expected particularly of those who practice in research, development or the more specialized or scientific phases of design and of those who will become the engineering leaders of one, two or more decades in the future? Engineering education needs to extend greater opportunities for self-development to those students with unusual talents without placing unrealistic demands upon other students having a more limited horizon. We need to break the lockstep of fixed curricula for students who vary far more widely than the proverbial square peg and the round hole.

The range between effective capacity for performing routine engineering duties and capacity for invention or for engineering leadership seems too great to be meet by a single fixed educational program. Until each institution has solved the problem of permitting talented students wide opportunity for developing initiative and for use of creative thinking we will need extensive experimentation in undergraduate engineering education.

Do You Know—

► The Fall Meetings of the ASEE this year will be held in conjunction with the Annual Meeting of the Engineers' Council for Professional Development at the Statler Hotel in New York, October 15–17. The conference program, open to all members of the ASEE, sponsored by the ECRC–ECAC, will feature the theme "Creativeness in the Arts" and "Creativeness in Engineering." Speakers will include a musical composer, an artist, and a poet who will discuss the process of creative thinking in the arts. Two prominent research directors will present a discussion of creative thinking in engineering. A psychologist will dissect the subject of creative thinking at a luncheon meeting. This promises to be an exceptional meeting which you will not want to miss. If you wish to attend, write to the Secretary for reservation forms.

► The General Council of the ASEE will meet on the afternoon and evening of October 14. A special meeting is also called for Division Chairmen and the members of the General Council representing Divisions to meet with the Executive Board at 10:30 A.M. on October 14. Arrangements will be made for meeting rooms for Divisions and Committees which wish to hold Executive Committee meetings at the time of the Fall meetings. The ECPD program on October 16–17 will feature open conference discussions on accreditation of engineering colleges, engineering manpower, and a luncheon discussion of the St. Lawrence Seaway Development. All members of ASEE are invited to attend the ECPD conferences as well.

► Those who attended the Annual Meeting at Gainesville will carry with them fond memories of a profitable meeting and a pleasant time. The programs of the Divisions, Councils, and Committees were directed at vital current issues in engineering education and proved to be highly stimulating. The Local Committee at the University of Florida did a superb job in planning facilities and entertainment for the guests. Dormitory accommodations and meals were exceptionally good and the mild heat was compensated by the advantage of being able to move from one air-conditioned building to another—a unique feature for ASEE meetings.

► Did you notice the attendance and interest exhibited at the new General Session at Gainesville on Monday afternoon at which Society projects were discussed? Vice President White and the Committee Chairmen who presented their reports in a stimulating and informative way deserve high honors for an efficiently conducted and highly interesting meeting. There has been considerable comment to the effect that this should be repeated. What do you think?

► The ECRC General Session on Wednesday morning with papers by Messrs J. W. Barker, C. F. Prutton, and H. L. Hazen, presented an unusually penetrating analysis of research as an aid to education. Also, the ECAC General Session on Thursday morning, with papers by Dean Roy M. Green and Professor C. S. Crouse on "Engineering Education and Engineer in Training Examinations," opened up a provocative discussion which endured for the balance of the Annual Meeting. Many thanks to Deans Walker and Lampe for the excellent job of programing these General Sessions.

► Mr. Karl McEachron, Sr. of the General Electric Company did an excellent job of summarizing the growth of unionism and the unity concept in the engineering profession at the Wednesday morning General Session, and President Woolrich's talk "Education and the Engineering Profession" was a distinctive highlight of the convention.

► As a member of the ASEE, you will want to read the report of the Committee on Society Finances. This report summarizes recommendations for a new dues structure. During the past year, the deficit in ASEE operations amounted to $1,688. It appears that a deficit of the order of $3,700 will be incurred next year. The Society is operating with rock-bottom overhead and every effort has been made to increase income. Our headquarters office currently employs only three secretaries. We have one staff member for every 1,500 Society members. Other major engineering societies have approximately one staff member for every 300 to 400 members. Society activities are expanding and this has placed a greater burden on the secretarial staff. Because of serious staff overloading, it is inevitable that additional secretarial help will be needed to assure satisfactory service.

There seems to be no escape from the fact that the $6.25 average dues per member is today worth little more than half of its value in 1947. The Society has endeavored to stave off financial difficulties by expanding its individual and institutional membership, as well as by increasing advertising in the Journal. The individual membership has approximately doubled during the past six years. But expansion of membership with the present dues structure cannot be regarded as an additional source of finances, since the cost of each additional member approximately equals the dues.

The numerous important projects which the Society has undertaken, as well as the expanded activities of its Councils, Divisions, and Sections have resulted in substantial increase in service to engineering education. Also, the ASEE is taking its rightful place in the coordinated activities of ECPD, EJC, and the American Council on Education and other professional societies.

► The two resolutions voted by the ASEE Committee on Evaluation of Engineering Education and considered by the General Council of the ASEE, relating to the establishment of bifurcated engineering curricula and the raising of minimum levels of accreditation of engineering curricula, will be published in the October issue of the JOURNAL. They will no doubt be controversial issues and you will probably want to study them carefully.

► In the event that you did not attend the Annual Meeting at the University of Florida and have not heard of the election results, the newly elected Officers of the Society are Dean L. E. Grinter, President; Dean B. R. Teare, Vice President in charge of Sections and Branches; Dean W. L. Everitt, Vice President in charge of ECAC; and Mr. George Farnham, Treasurer. Dean Eric Walker and Vice President W. C. White carry over for another year as Vice Presidents of ASEE. The Council members are listed on page two of this issue of the JOURNAL.

► Next June, the Annual Meeting will be held at the University of Illinois, June 14–18, 1954. You will want to reserve these dates and plan to attend. A number of outstanding features are already shaping up for this Annual Meeting program. We'll tell you more about these in a later issue.

► The Committee on Evaluation of Engineering Education has suggested that the Divisions of the ASEE consider directing their Annual Meeting programs next June toward evaluation of engineering education in their particular curricular areas. This Committee hopes to have a preliminary draft of its report completed and reviewed by the institutional committees in engineering colleges throughout the country by next February or March.

► If you are interested in preparing a paper for submission at the Annual Meeting, may I suggest that you get in touch with the Chairman of the particular Division. Usually the Divisions shape up their programs in November and December preceding the Annual Meeting.

► Watch the October issue for a complete roundup of Council officers and Division, Committee and Section Chairmen.

► Are you interested in receiving copies of the newly completed "Manual of Graduate Study" or the "Report of the Committee on the Improvement of Teaching"? Copies of these can be obtained from the Secretary's Office, the price of the Graduate Manual being 50¢ and that of the Report of the Committee on the Improvment of Teaching being 15¢ each or $8.00 per hundred. All orders should be accompanied by a check remittance.

► You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College., State College, Pa. The price is $2.50.

► Did you notice that the two winners of the Young Engineering Teachers' Paper Contest were both from small western colleges? They are Lee Harrisberger of the University of Utah and Ralph Smith of San Jose State College. The General Council voted to repeat the YET Paper Contest again this year. There were over 75 entries indicating widespread interest in this activity. Next June, the two top awards will again be presented at the Annual Banquet. Here is an opportunity for the young faculty members to gain distinction. The rules will be published in the October issue of the JOURNAL.

► The other award winners included President Harry S. Rogers, recipient of the Lamme Award; Professor Edward Obert, Recipient of the George Westinghouse Award; C. W. Beese, Technical Institute Division Award; Carl L. Svenson, Engineering Drawing Division Award.

► This year the Young Engineering Teachers' Committee will take over the Membership Drive. We hope that you will give them wholehearted cooperation. The Officers and General Council are particularly anxious to integrate the young faculty members into Society activities, since this will enable them to broaden and enrich their professional outlook. It will also bring to ASEE that element of vigorous, unorthodox thinking which is characteristic of youth and which is so vital to progress.

► Our last year's President, Dean Woolrich, and his wife left three weeks after the ASEE Annual Meeting for a relaxing trip to England, the Scandinavian countries, and Continental Europe. Our best regards go with them. Last year, Dean Woolrich attended every ASEE Section Meeting west of the Mississippi River except one (which was attended by Vice President Boring). President Woolrich was also responsible for initiating a number of important Society projects which will come to fulfillment in the years ahead. These include studies in Ethics of the Profession, Recognition and Incentives for Good Teaching, and an abrupt awakening of the engineering profession to the growing dangers of unionization.

► Each year, when Officers of ASEE retire from top-echelons, we look forward hopefully to their continued participation. This year, Dean Lampe and Mr. M. M. Boring retire as Vice Presidents. They have both devoted a great deal of time and constructive effort to the organization and supervision of ASEE activities. Also, our retiring Treasurer, Mr. Skelley, has rendered exceedingly helpful advice and assistance throughout three years of competent service. To all of them go our many thanks for their cordial and efficient service.

► The Committee on Associate Institutional Membership, under the able Chairmanship of Jesse McKeon, has come through with 60 new Associate Institutional Memberships, consisting of large companies which have substantial engineering operations. Congratulations on the excellent job. It is the policy of ASEE to develop closer working relationships with industry. A long-range program of mutual enlightenment and assistance can be of great benefit both to the engineering colleges and to industry.

► Watch for this column in October. At that time we will give you more news of projected ASEE activities for the year ahead.

Best Regards,

ARTHUR BRONWELL, *Secretary*

Report on UPADI Convention

The Second Convention of the Pan-American Federation of Engineering Societies (UPADI) was held in New Orleans, La., August 25 through 29, 1952. The Engineers Joint Council and the Engineering Institute of Canada were co-hosts. Dean L. J. Lassalle of Louisiana State University and Dean S. S. Steinberg of the University of Maryland were the official delegates of A.S.E.E. Since Dean Steinberg is an honorary member of the Society of Engineers and Architects of the Dominican Republic, he was asked to serve also as an official delegate of that Society.

The total registration was 314 and the delegates represented 14 countries, including Canada and 11 Latin American republics. The sessions were held in the McAlister Auditorium of Tulane University. Carlton C. Proctor, president of the American Society of Civil Engineers, was elected president of the Convention, and Luis Giannattasio of Uruguay was elected honorary president. James M. Todd, past president of the American Society of Mechanical Engineers, was chairman of the local organizing committee and also headed the United States delegation. Dean Lassalle was Chairman of the Technical Program.

Dean W. R. Woolrich, president of A.S.E.E., presided at the technical session dealing with engineering education. At this session, papers were presented by deans of engineering schools from Canada, the United States and Latin America. Dean K. F. Tupper of the University of Toronto spoke on Engineering Education in Canada; Dean Steinberg and Dean Woolrich spoke on Engineering Education in the United States; and several delegates from Latin America discussed the status of engineering education in their respective countries, including Brazil, Cuba and Peru.

At the business sessions, a Constitution and By-Laws for UPADI was adopted, and a UPADI Fund was created for financing the organization.

In addition to many social events, a number of inspection trips were arranged for the delegates, including the Kaiser Aluminium Works, the Port of New Orleans, the U. S. Experimental Waterways Station at Vicksburg, Miss., and the Freeport Sulphur Company.

It was decided to hold the next Convention in 1954 in Sao Paulo, Brazil, when that city will observe its four hundredth anniversary.

S. S. STEINBERG,
Dean, College of Engineering,
University of Maryland

Education for Professional Engineering Responsibilities *

(From Origin to Present Challenge)

By W. R. WOOLRICH

Dean of Engineering, University of Texas

The Sixty-First Annual Meeting of the American Society for Engineering Education is convened here at the University of Florida to carry forward the business and educational objectives of the Society and also to renew old friendships and establish new fraternal contacts on this attractive campus dotted with its many buildings of southern architecture. Actually we are punctuating the end of the sixtieth year of what originated as the Society for the Promotion of Engineering Education during the World's Fair in Chicago July 30–Aug. 5, 1893. For the information of the younger members, the original society merged with the Engineering College Research Association in 1947 to form the present American Society for Engineering Education.

If today we would review the rise and development of the profession of engineering for civil life we could perceive the first evidence of a group concern and comradeship when John Smeaton of England called together sixty-five men with engineering interest for a meeting at King's Head Tavern, Holborn, London, in March 1771. Of this total number only fifteen were said to qualify as men of professional engineering stature. In addition to Smeaton, these fifteen included Joseph Whitworth, Joseph Priestley, Mathew Bolton and James Watt.

To those who are interested in industrial history the year of 1771 can be associated with the developing industrial revolution of Western Europe.

The record shows that this first engineering society was dominated by John Smeaton; and when, in 1792, some of the younger members of his group challenged his leadership, Smeaton's personal hurt was so intense that he disbanded what had become known as the "Smeatonions."

The experience of Smeaton may be regarded as the first attempt of an individual engineer to regiment the members of his profession. It was an example of what could be anticipated by any subsequent leaders who failed to recognize that, in dealing with the active members of a creative profession, each individual member cherishes greatly the freedom of thought and action that true professional distinction implies.

On April 15, 1793, a new organization was assembled in London with many of the same members who had made up the disbanded Smeatonion group. It took the name of The Society of Civil Engineers. John Smeaton had participated freely in the reorganization plan but, ironically, died just before the organization of the new group was effected.

The record shows: "It was conceived it would be a better plan that the members should dine together at a late hour, after attendance at Parliment and pass the evening in that species of conversation

* Presidential Address, ASEE Annual Meeting, University of Florida, 1953.

which provokes the communication of knowledge more readily than it can be obtained by private study or from books alone." It is of interest that for many years after the founding of this new organization, at each fortnightly dinner meeting at the Crown and Anchor on the Strand, "a pious tribute was always paid to the deceased John Smeaton."

Society of Civil Engineers

This Society of Civil Engineers was constitutionally limited to "Forty-eight engineer members and twelve honorary members." Although its effectiveness was dwarfed by its limited membership it is still existant in Great Britain today but functions only to honor British Engineers of distinction who are selected under the limitations of the original constitution.

The principal weakness of the Society of Civil Engineers was this limited membership. The industrial expansion of Great Britain co-incidental with the industrial revolution created a demand for an organization with a broader base. Under the leadership of Thomas Tredgold the Institution of Civil Engineers, with more professional objectives, came into existence January 2, 1818. One of its early problems was to find some satisfactory specifications by which the members should be selected. This gave occasion for the writing of a suitable definition of engineering by Tredgold, which definition has withstood one-hundred-thirty-five years of progress without too much to add or subtract from it even in 1953.

The Institution records show that of their first ten presidents only two had the advantage of a University education and these two were from Scottish institutions. Engineering education for most of those who achieved distinction was acquired by the "pupilage" procedure so common in Europe until the Twentieth Century.

For fifteen years after the formal organization of the Institution of Civil Engineers there were discussions in both Great Britain and North America about the possibilities of a system of formal engineering education. France had had some success in instituting specialized science and engineering schools. Military colleges patterned after the French system had been set up on both sides of the Atlantic Ocean. In the United States, Norwich University and Rensselaer Polytechnic Institute next took the initiative and offered work in Civil Engineering. University College, the University of London, followed by appointing a Professor of Civil Engineering in 1828; but due to the opposition from the Professor of Physics of that institution, no formalized curriculum was made available until 1841. In the meantime King's College, London, appointed a Professor of Civil Engineering and in 1838 had a recognized curriculum for Civil engineers—thus establishing its claim to being the first University in Great Britain to offer and follow through an engineering curriculum.

This first epoch in the education of professional engineers, a period when volunteer societies worked together with those who had engineering apprentices, followed a plan of education by the "pupilage" system. This system was slowly to give way to the formal procedures of education in the classroom. A long fight was still ahead, however, since most of the Universities of the world would resist the invasion of both the sciences and the engineering courses in the published catalogues. Of these two, engineering was the least palatable to the educator with the Liberal Arts background.

World Congress in Engineering

The next epoch in the development of engineering might be considered as extending from the beginning of the period of the earliest University education in engineering in Great Britain and North America to the World Congress on Engineering at the World's Fair in 1893. On both sides of the Atlantic the debate went on from year to year between the champions of liberal arts education and those who supported the sciences and engineering. In the United States, Union College

had sufficient courage to introduce (1845) an engineering curriculum. The real break in the opposition to engineering education in the Universities within the United States appears to have come, however, in 1851 and 1852, when four of the leading American Universities admitted to their catalogues curricula leading to an engineering degree. The record shows that engineering was instituted at Dartmouth in 1851, and at the Universities of Michigan, Harvard, and Yale in 1852.

Ten years later the Federal Land Grant Act was signed by President Lincoln and the United States was ready for an unprecedented expansion of public higher education, especially in agriculture and engineering. Within another ten years (1872) seventy colleges were offering engineering degrees in the United States.

The rapid expansion of engineering education in the United States in the post-Civil War period was accompanied by many examples of poor judgment in setting up engineering curricula. The universities and colleges offering engineering education had widely differing objectives and backgrounds. Their differences in purpose were as varied as the origins of their operating funds. Further, the individual conceptions as to the objectives of engineering education by the newly appointed deans of engineering colleges were very far apart.

In the Canadian provinces, the policies for the education of engineers were more conservative during this period. They embodied much of the European pattern of emphasizing the fundamental sciences but did not overlook the fact that, as frontier regions, they must fortify their students with the ability to do much with little.

In Great Britain a dual system was in the making. Those who were privileged to study at some of the *Universities* could follow an engineering curriculum leading to a formal degree. However, others who might follow a similar curriculum in a *technical college* would be awarded, upon their completion of the outlined program, a diploma only.

Formation of SPEE

The formation of the Society for the Promotion of Engineering Education at the completion of the World Engineering Congress in 1893 was most fortuitous as the beginning event in a new, or third, epoch in engineering education. It constitutes a milestone that we can celebrate with real pride today. The Society has for the past sixty years been an inspirational and coordinating force. Its members have given unselfishly of their time and talent to upgrade their profession. Today our co-workers in the other learned professions and engineering educators of the other nations envy our Society for its record of service to the human race and to our national progress.

Within these past sixty years, engineering as a profession has come of age. The services rendered to the people of North America by the engineering educators of both the United States and Canada throughout World Wars I and II, plus the far-reaching contributions made by the thousands of professional engineers whom these same educators have nurtured through their years in college, bespeak a citation far beyond human expression.

As we look forward into what could well be a distinctive fourth epoch in engineering education for professional engineers, there are many signs of a promising future of our chosen profession. The most assuring of all of these indications is the high type of leadership to be found in our engineering colleges of both the United States and Canada. I am confident that I speak with the approval and support of all the members of your elected and appointed officers when I express complete confidence in the administrators and teachers of our engineering colleges in America.

They and we are not so naive, however, as to fail to recognize that there are some forces influencing our engineering profession about which we need to be most watchful.

Present Threat

Throughout the past 183 years of professional engineering endeavor, during which there has been general concerted effort of engineers to achieve professional distinction, we also find some minor attempts to impede professional growth. No force from within, however, has formerly posed as great a threat as does the present activity of the Engineers and Scientists of America. They are now attempting to gain the ear of the U. S. Congress and the Secretary of Labor to the effect that their organization may be named "to speak for the approximately 400,000 employed non-supervisory professional engineers and scientists who are so vital to our national defense and to our way of life."

Printed statements by President Joseph Amann of the Engineers and Scientists of America Union in the supporting labor journals give definite evidence that the Union seeks to place the average engineer in a class with tradesmen and definitely on the workman's side of the collective bargaining conference table.

I would like to re-emphasize the editorial statements given through the *Journal of Engineering Education* in the April 1953 issue: "The engineer of less than average ability can generally be given a salary lift by a collective bargaining agreement. In the levelling off process he gains at the expense of those who are above the average. When a union is first established there may be even a higher average wage than could have been obtained by individual contract by superior engineers. But the future is not too bright in collective bargaining for the advancement of men of creative genius and individual professional abilities. Collective bargaining is never inspirational to the man of creative talents, and recognition within a union cannot be readily afforded him other than as a part of a collective group."

On the other side of this question there is a large segment of American industry that has failed to be realistic in its adjustment of salaries and wages of its employed professional engineers. The salaries for beginning engineers have risen at a much faster ratio than have the increments of advancement for qualified engineers of five, ten, and twenty years of service in some companies within this unrealistic industry segment to which I refer. Actually, in some instances, the starting salary curves for recent graduates have intersected the average salary curve of men of some years of service and experience within the engineering profession. It is the American industrialists of this negligent segment who furnish bona-fide reasons for some union or other group to challenge the administrative competence of the managers concerned.

Many individual members of the Relations with Industry Committee of the American Society for Engineering Education (ASEE) are performing an urgently needed service in encouraging the revision of the salary scales for engineers of several years service and in securing the advancement and recognition of these men commensurate with their professional contributions.

The employer of the professional engineer, whether he is with a University, a Federal or other government agency, or an industrial concern, should provide the incentive and recognition for advancement within the profession wherever possible. If industry and government are going to avert the growth of unionism within professional engineering circles, then the compensation offered for engineering service must be commensurate with the abilities and contributions of each individual within the profession. *It is essential that the salaries of men of accomplishment and years of service shall be an incentive to the men entering the profession.* This calls for a wider spread in compensation between the salaries of the beginner and the engineer of several years of competent service. This spread should be commensurate with their respective values to the employer.

We within the engineering profession,

together with the employers of engineers, must face this problem with understanding and positive constructive action. Those within the union circles who would speak for us at the conference table are alert to the weaknesses of the salary scales of some industrial groups and are ready to move in.

Effective Answer

The most effective answer to unionism is a full recognition by the employer of each individual as a professional engineer. The professional engineer is usually a man who prefers freedom of thought and action to that of herd classification, but he should—and does—expect adequate consideration for his specialized services.

Another economic force that can threaten the higher achievement possibilities of engineers and scientists in the United States is the current zeal of the Armed Services to put every able-bodied engineer and scientist in the Reserve Officers Training Corps of each campus. If this is judiciously carried out it can be mutually beneficial to the military and the universities, but there are evidences that our industrial development of the United States may be sharply curtailed by military short-sightedness.

While assurances have been forthcoming to this Society that interference with the engineering curricula by contracting officers representing their respective services will not be tolerated, and further adequate provision was promised that men would be assigned duty in their fields of specialization after conference with the Deans concerned, we should make a continuing pool of our engineering graduates to determine the effectiveness of those agreements.

The per cent of engineering graduates that will be required to serve as officers in some branch of the military is rapidly increasing. The number exempt from such service is very low. The Manpower Committee of the Society is rendering most valuable service in appraising trends and advising both military and civilian agencies in Washington as to the future needs and reservoirs of engineering man power in the United States and in suggesting a judicious handling of the problems involved. In this field of the effective use of the available man power, it is of further importance that we do not overlook the man power problem in our own teaching ranks.

It would be well for all of us associated with the American Society for Engineering Education to give serious thought to the compensation of engineering teachers in relation to the salaries currently being paid by American industry.

Shortage in Instructional Manpower

Recently, in a newsletter sent to many of you, we called attention to the serious impending shortage in instructional manpower. The combination of in-elastic college financial budgets, especially in state-supported schools, together with the rising pay scales of industry is causing the desertion of the engineering teaching profession to industry by well trained engineers at an accelerated rate.

More recently President Edwin S. Burdell of Cooper Union has emphasized the same problem in an article in the June number of the *American Engineer*. He called attention to the fact that many evening students currently enrolled in engineering colleges are earning salaries higher than the salaries received by their profesors. Quoting President Burdell: "The inequity of such a situation is obvious. When a man sees those whom he is teaching making far more than he does even before their student days are over, he naturally begins to wonder if he should not step over to the other side himself.

"To state it bluntly education faces a new competitive challenge in industry's growing understanding and application of human relations, the doctrine that wages and fear of unemployment are man's only incentive, is rapidly being superseded as we move into the second half of this century. Security and human dignity, once the chief justification of the low pay scale

of the teaching profession, are now to be found in industrial personnel policies and practice."

Industry itself, in order to assure a supply of adequately educated engineering graduates, may find it necessary to loan personnel for engineering teaching or, through the appropriate foundations, to supplement the teaching salaries of the engineering teachers especially in the upper ranks in order to keep these men in the teaching profession.

The American Society for Engineering Education Council has authorized the appointing of a special Committee on Instructional Manpower to study this problem and, if the committee finds it advisable, to meet with industrial leaders to try and find the answer to this urgent and critical problem.

Your President is appointing such a Committee and I hope it will go into action immediately. If some definite action is not taken, we can expect there will be a serious deficiency of several hundred engineering teachers when the fall semester or term opens in September 1953.

A Higher Goal

May we turn now from the commenorative, the historical, and the analytical to a look forward to an even higher goal of achievement in the future for the aims and objectives of the teaching of engineering as a profession.

In 1952, Past President Hollister with Council authorization appointed a special committee on the evaluation of Engineering Education. Through the sponsorship of the Society for the Promotion of Engineering Education, previous periodic analyses and appraisals had been made of the aims of the Society under such committee titles as the Aims and Scopes of Engineering Curricula in 1940, and the Engineering Education after the War in 1944.

The happenings of scientific moment that have occurred between 1944 and 1952 justified a more searching study of the aims and objectives of engineering education. Especially was it hoped that an honest attempt would be made to put date marks of the future needs in engineering education for five, ten, fifteen, and twenty-five years beyond what you and I are teaching in the classroom today. How great is this inertia lag in engineering classroom teaching today and what are the probable remedies?

Momentous questions naturally arise in any such study. The members of the many institutional committees who have been studying these problems realize this. Yesterday we had the benefit of some of the thinking of the main committee when it was presented by the Committee Chairman Dean L. E. Grinter at the Annual Business Session.

There is always danger in such a study that iconoclastic action may prevail as a way out from some difficult problem. As emphasized in the papers presented during the Centennial of Engineering in Chicago, there is much to be preserved in an engineering education system that has made many great professional engineers in the United States and Canada and that is now the envy of the world for its total effect upon industrial productivity of these two nations.

The engineering profession has come a long way since the Smeatonions with their fifteen engineers and fifty hopefuls organized the first group that considered themselves professional as they sat around the tables of King's Head Tavern, one-hundred eighty-two years ago. We witness the first third of that period passing away before the English-speaking world recognized that any formalized technical education was desirable for professional engineering. The next sixty years were spent by the maturing profession in breaking through the crust of scholastic imperialism of the Liberal Arts College leaders and in earning recognition as desirable associates for men of letters in Universities and Colleges. In the passing of the last third of these one-hundred eighty-two years the proceedings and papers of the American Society for Engineering

Education and its predecessor, the Society for the Promotion of Engineering Education, tell a realistic story of the earnest efforts of a great galaxy of American engineering educators and professional engineers who have given this Continent the best in engineering education.

Committee on Evaluation of Engineering Education

Through the Committee on Evaluation of Engineering Education there comes before us the question as to what course work should go into discard, what retained, and what new source material should be recommended for our several curricula. Of one fact many of our members are certain—the life stream of the profession should flow deeper, not wider. We need to stop following the pattern of the amoeba by incessant splitting off and subdividing into new engineering degrees, ad infinitum.

Some have raised the question of whether production, processing and operation can lead to a professional engineering status with the same level of distinction as that achieved by a more fundamentally scientific approach.

It would seem that we should take a positive stand and recognize full professional stature is possible whether we ascend to the goal of professional engineering by the production management or the scientific engineering route.

If any one of the curricula has acquired unessential subject material then we should be courageous enough to operate upon such a course program even if it is now accredited. Most curricula could be greatly benefited if we elevated the level of their fundamental substances both in the sciences and humanities.

Amrican Engineering Productivity Genius

The reputation of engineering education in North America has been established primarily on the productivity genius of our American engineering college graduates. Europe and Asia recognize us for this genius in production. A large segment of our registered professional engineers of the United States and Canada belong to the group of graduates who have earned their professional status by production, operation, construction or management.

In the area where Europeans and British engineers are the strongest, that is in the scientific phases of engineering practice, many of the managers of industry there report that such a fundamental science training for industrial production or construction should go no further than the Bachelor of Science level.

The British testify that the usefulness of the men who have advanced degrees in fundamental engineering science is not in the fields of production. They would recommend them to the government and industrial research laboratories primarily as researchers and technologists. This is largely due to the European program of advanced engineering education.

In North America it would seem that we could profitably reduce the number of undergraduate curricula leading to the Bachelor of Science degrees; then, for the advanced degrees, two paths might profitably be provided in *each* field of engineering to lead to a high level goal—the one in production, construction and operation, the other in engineering sciences and research.

By either path an understanding of the principles of management should be an essential part of a professional engineer's preparation. Management is a part of all walks of life where human beings must work together.

The work of the American Society for Engineering Education for the next sixty years should represent a fully rounded program of undergraduate and graduate study. The engineering sciences must be advanced in most engineering curricula, but this should not be at the expense of our accomplishments in industrial engineering and management. All Western Europe and much of Asia are determined to try to overtake us in industrial activity. We should not reduce our rate of advance-

ment in industrial enginering but raise the level of what we have in that field as well as direct our attention to new high levels of accomplishment in the engineering sciences.

The financial capital of the world has moved to the American Continent within the past two decades.

Those of us who have studied Europe at close range are convinced that the spiritual strength of America with its freedom of religious thought and action is much more virile and effective than that which prevails in nations that still stubbornly cling to state religions.

Nationally our march of progress should envision a nation growing deeper in its moral and religious foundations and fully capable of directing the distribution of our financial resources through a personnel well educated in the principles of science and engineering from the basic fundamentals to their various applications. These should be effectively applied to the management of men, the development of power, the utilization of materials, the communication of thought, the transportation of man and the distribution of his goods.

Our responsibilities to reach these goals would appear to be a most fitting challenge in the education of professional engineering for the next three score years. In our aspiration to work toward these goals may we keep the profession free; free to act, to think, to speak and to believe, so long as in these activities each member will remain true to the principles and within the framework of our American way of life.

Sections and Branches

The Spring Meeting of the **Middle Atlantic Section** of the ASEE was held on May 2, 1953 at the University of Delaware.

The morning general session was opened by David L. Arm, Dean of the School of Engineering, who introduced Dr. John A. Perkins, President of the University of Delaware. After the address of welcome, Dean Arm introduced Professor C. F. Bonilla, Chairman of the Section, who then introduced Dr. Jess H. Davis, President of Stevens Institute of Technology, whose talk, "The Contribution of the American Engineering College to American Industry and Culture," featured the morning session.

At the business meeting which followed the main talk, the minutes of the meeting held at Manhattan College were approved as was the financial report. Professor M. T. Ayers, Chairman of the Committee on Meetings, included in his report the notice that the Fall Meeting would be held at the University of Pennsylvania, December 5th.

The afternoon session was divided into the following group meetings:

(a) Educational Aspects of Engineering Research in Universities
(b) Services Offered by College Placement Bureaus
(c) Graduate Instruction by Means of Off-Campus Courses
(d) Undergraduate Statistical Training for Engineers
(e) Aids to Undergraduate Instruction
(f) Preparation Required in Engineering Drawing for Industry

Before dinner, President and Mrs. Perkins greeted the vistors at a reception given in Warner Hall. The University Glee Club furnished a musical interlude at the end of the dinner and previous to adjournment.

The Ladies' Program included a tour of the campus, lunch at the du Pont Country Club, and a visit to the well known Longwood Gardens. They returned in time to join with the men and attend the reception and dinner.

The following three papers were given at the ECRC General Session meeting at Gainesville, Florida, June 24, 1953 under the chairmanship of Eric Walker, Vice President of ASEE and Dean of Engineering, Pennsylvania State College.

Theme: Encouragement of Fundamental Research as an Aid to Education and Engineering.

Opening Remarks

By DEAN ERIC A. WALKER

Chairman, Engineering College Research Council and Vice President, ASEE

The Gainesville newspaper welcomed the American Society for Engineering Education and the Engineering College Research Council on the opening of our convention by stating, among other things, that the budget of the School of Engineering at the University of Florida this year amounts to $1.5 million and of this some two-thirds was devoted to research. This same ratio of research to teaching cost is being repeated in many of our engineering schools and in many cases the business of research is in danger of overshadowing the business of education. Research today is big business in the colleges as well as in the industrial world.

In this year of 1953, the United States will spend well over $3 billion on research and development, or almost one per cent of its gross national product. Of this money, the greater portion comes from the Government. In 1952, approximately $1.8 billion was so appropriated (mostly by the Department of Defense) and of this, $300 million has been identified as being allocated to the schools and colleges. Unfortunately, the figures are somewhat deceiving for about $180 million of this is spent by research institutes and large Government-owned but college-operated laboratories which have little or no connection with an educational function. This leaves about $120 million, which is spent in such a manner that it has an impact on the educational process. Its effect can be extremely important.

We are all well aware that there is a change in Washington in attitude towards Government spending and we are beginning to feel that there is a change in attitude towards research itself. In any event, we feel certain that the research and development budget is due for drastic cuts. This then raises the question as to how soon and where they will fall. The Government spends its research and development money in three large types of organization—industrial laboratories, laboratories that are Government-owned and operated, and universities. The types of research spent in each differ in important particulars.

The research done in industrial laboratories is often of a more practical nature, leaning towards development and often coupled with a specific weapon design and production. It seems fairly obvious that the Department of Defense will not cancel a research project which appears to be leading to a new weapon, especially a weapon for which there is an operational need and funds for its manufacture. This consideration alone will protect many industrial research contracts. The work done in Government laboratories is often that for which there is no industrial application or of the type which requires large, expensive proving grounds and other in-

stallations which have little industrial use. Such laboratories are staffed by civil servants and usually by their very nature laboratories of this type must be operated to keep them workable in case of emergency. These factors will give them considerable priority on Government research funds. This leaves the colleges as the easiest source of a paper saving. Some members of the Engineering College Research Council feel that we may have to bear the initial onslaught of such reductions. Such cuts will be very hard on the colleges for many, admittedly, have tooled up more than is wise and have made more commitments to personnel than they can carry if a sudden reduction should be called for. All of this risk has been accepted as part of a genuine effort to help the Government in time of emergency.

We note with some pleasure a shift to the more fundamental types of research in the colleges and we have been much pleased with the increased activity of such organizations as the Office of Ordnance Research of the Army, the Scientific Research Office of the Air Force, and the National Science Foundation, as well as the continued activity of the Office of Naval Research which has long been known as an ardent supporter of college work. It is our belief that the Armed Services and indeed the Government and industry receive a generous return for money spent on college research. Figures compiled on the cost of supporting a research worker show that in general a university researcher costs about half as much as one working in Government or in industry, and we like to believe he is just as productive.

Admittedly, there is one field in which the engineering colleges have not done their share and one in which the Engineering College Research Council is searching for ways to be more helpful. That is in providing research assistance and know-how for small industry. Some of us have been much impressed by the productivity of the American farmer which is far higher here (measured on a yield per agricultural worker basis) than in any other country. This fact cannot be divorced from college activity in agricultural research and the dissemination of the results of this work by pamphlets, meetings, and the spoken word to the individual farm operators. There are many small business men operating in this country without any such help or advice. Previous attempts to assist them by the engineering experiment stations, divisions of industrial research, and the Department of Commerce, have been too small to measure the beneficial effects. It is our belief that in this area lies one of the large opportunities for the engineering colleges of today.

Although there seems to be general agreement that engineering colleges ought to concern themselves only with the more basic types of research which lead to an advancement of the frontiers of knowledge, there are some members of the Council who feel this is a too narrow and restricted point of view. Their arguments run something like this: The profession of engineering is essentially concerned with the *creation* of new machines, systems, and materials which the people want. Therefore, the individual engineer must be creative and engineering teachers should, if possible, teach their students to be creative. This they cannot do without having a chance to practice creativity themselves. In other words, a teacher who is not creative cannot impart such knowledge to a student. Many engineering teachers practice creativeness by consulting; others by doing research. But should not a mechanism be provided for all engineering teachers to practice engineering? If this is so, is not the best way to do it to provide an organization as part of the engineering school, such as a division of engineering research which would provide room for practice? Such an organization might operate on similar lines to the clinics and hospitals associated with our better medical schools. I warn you that this is only preliminary thinking and the Council is not yet prepared to formulate a statement of policy

but these ideas are offered for your consideration with the hope that you will be stimulated to give some thought to this important problem.

It is with these facts in mind that we have assembled the three speakers who are here this morning, who can talk from three points of view—namely, industry, education, and the foundations, on the impact of research on education. The careers of these three men show strong similarities; all have taught in colleges, all have given part of their lives to public service, and all have been leaders in their own fields of science. I am sure you will find their remarks stimulating.

From the Viewpoint of the University *

By HAROLD L. HAZEN

Dean of the Graduate School, Massachusetts Institute of Technology

In preparing these remarks on Encouragement of Fundamental Research as an Aid to Education in Engineering, I found the subject somewhat elusive despite its apparent obviousness. On the one hand, there are probably few thoughtful engineering educators who disagree in principle with the implication of the program title that fundamental research can be an aid in engineering education. If so, why do we need to discuss it? On the other hand, the practice in many of our schools indicates belief that the principle is valid for some *other* school, but not for *ours*. Or the feeling may be that while good in principle, research is not possible for us. Or again, we may believe in it, and want it, but find that research doesn't come to us. How can we tackle this subject in such a way as to shed light on the possible achievement of an end that most accept as good?

As a starting point I should like to draw upon work of the ECPD Education Committee in its visitation and accreditation program. While the reports of its inspecting teams are strictly confidential, and for very sound reasons, I believe that I am violating no confidence if I give to you synthetic extracts from reports characterizing two strongly contrasting schools. In these, I shall by selection overemphasize the research aspect *per se;* nevertheless, evidence of creative professional activity is regarded as an important criterion of professional stature of the faculty.

In the report on School A we find: "I was impressed with the forward-looking spirit of the staff in the Mechanical Engineering Department. Three full professors are guiding active research projects. Professor Q's work in dynamic stresses is significant although his financial support is limited and space is at a premium. His experimental equipment shows a high ratio of ingenuity to cost, but the ABC Company has become interested in the work and is making a small grant for additional support next year. Several publications have come out of these and the other departmental projects in the past few years. Recently Professor S has been consulting for a small manufacturer on some very interesting problems of heat transfer and he has become a recognized authority in this area.

"These activities are reflected in the handling of the senior electives taught by these men. During the past three years the core courses in Mechanical Engineering have been critically reexamined and revised to build on the students' mathematics and physics more directly. Some of the senior laboratory work ties in with Professor R's project on fluid flow around hydrofoil surfaces. Laboratory equip-

* ECRC General Session ASEE Meeting, Wednesday, June 24, 1953.

ment is good though not elaborate, and shows ingenious adaptations to permit unusual measurements.

"While some of the staff are not active in research and are in fact devoting their energies largely to standard undergraduate teaching, one senses in the department an alertness to and appreciation of new developments in the field and a rigor of thought and fundamental approach to the undergraduate teaching that provide a good foundation both for the students who are going directly into industry and those who are going on to graduate work. Incidentally, last year several seniors went to graduate schools. This department appears to be in a healthy condition and is growing with the field."

The above are extracts from the one type of school, which we can call Report on School A. Let us now look at excerpts from the Report on School B: "This inspector was impressed by the spirit of undivided devotion to undergraduate teaching found uniformly among the staff of this department. The faculty members are close to the students. The department has high morale despite the seriously low salary scale that was marginally low even before the inflation of recent years.

"The inspector reviewed class outlines, sample problems, actual examinations and laboratory reports. Courses have conventional content and the textbooks are among those widely used.

"Teaching loads are heavy, running in the worst cases to 18 or even 20 hours per week, including some laboratory. The faculty almost uniformly commented that their teaching load kept them busy all the time, and that they welcomed summer teaching assignments as a means of supplementing the low salary. While several of the faculty are members of one or two professional societies, they seldom attend meetings and have taken no active part for several years. The institution finds it very difficult to pay the expense of having them attend professional meetings, though the policy is to do so if a faculty member has a paper to present. However, the heavy teaching loads and preoccupation of the faculty with purely undergraduate teaching largely preclude any other professional activity. One minor consulting connection is of routine character.

"Possibly as a consequence of this lack of professional activity on the part of the staff, the courses have changed very little in the past 15 or 20 years. The laboratory equipment while adequate for elementary routine experiments is sadly out-of-date. There was little evidence of interest or ingenuity to adapt equipment or to improvise means to enable students to explore at least in an elementary way the newer point of view in this area.

"All in all, the picture is one of devoted, even dedicated loyalty on the part of the faculty to the school, the students, and to their work. But the department contains no inspirational quality and is 20 years out-of-date. Some of its work is more vocational than professional in character. In its way the work is well done, but it lacks the forward-looking and scientific point of view, the stimulus of new ideas. The professional influence on students has a vicarious, once or twice removed, quality. Perhaps most serious is the apparent complacency with, or indeed unawareness of, this static state of affairs."

In these brief extracts I can only suggest the cumulative impression formed as one reads the entire report. While I have contrasted School A with School B, a comparable contrast sometimes appears between different departments in the same school.

Foundations for Professional Growth

Both schools, of course, have loyal groups of alumni and enthusiastic supporters among the nearby industries. Both have had little difficulty in recent years in placing all of their graduates. Yet one senses that the quality of foundation that has been laid in the students for future professional growth is widely different in the two schools and that the student who has the natural intellectual capacity and character for important pro-

fessional work has been short-changed in School B. Of course the vigor and capacity for adaptation of youth are such that later stimulus sometimes inspires an able student from School B to develop qualities of professional leadership. One cannot but feel, however, that although the student of School B, like the child who has been nurtured on an ill-balanced and vitamin-deficient diet, may ultimately succeed, he starts with a serious handicap.

Is research the only and magical difference between A and B? Will School B plus research equal School A? The answer is obviously "No." The difference is fundamentally the difference in men. Yet research is a very significant factor and the research spirit a vital factor of difference.

What can School B do about its situation if it wants to? The first requisite is the conviction of the administration, especially the top administration, that the school must provide in the educational diet some of the intellectual vitamins as well as the essential calories. The president or dean must infuse this conviction throughout critical spots in the institution. Such a conviction cannot readily be infused into the oldsters, with perhaps a few notable exceptions. We oldsters are usually non-responsive if not indeed allergic to new attitudes. It is the younger members of the staff to whom he must turn for the responsiveness to the stimulus to do new things. The president or dean may, of course, pull in a key man from elsewhere as a dean or department head who has this forward-looking and creative spirit to build up the activities of which he is given charge. But the real working groups are almost inevitably found among the younger men.

In building up this spirit, it is vital to pick and back the right kind of young person for this job. One cannot pick him with certainty, but only with reasonable probability of success. This promising fellow is the obviously able youngster who has new ideas and can make them work. He has imagination, intellectual power and ability to produce. He is interested in students and teaching, but he is impatient with routine repetition of a set pattern as his entire diet. He insists on the opportunity for creative professional work.

But let's be frank with ourselves. Often this young person will be an uncomfortable fellow to have around. He has too many ideas for changing things. Many of these ideas will be wild and impractical, even as judged by the progressive minded dean. He will be impatient with the orderly processes of institutional routine. He will get people annoyed at him because in his enthusiasm he overlooks the fact that human individuals are involved, and that tact and consideration for the rights of others are required in the prosecution of even the best ideas. He will have the department head and occasionally even the dean in hot water because of his brash actions.

Furthermore his salary will be a real problem. The market price is high on this kind of man and the non-financial attractions of academic life, real as they are, have a limit as an alternative to salary. To get and hold this man requires breaks in the customary policy line. To do this without weakening the morale of the organization takes the measure of the president's stature and wisdom.

But in spite of all the administrative discomfort he is likely to bring with him, this young man is the essential element. Without him the strongest administrative desire for the creative spirit in his institution goes unsatisfied.

The second requisite for developing the research spirit is the opportunity for the staff to engage in such activities. This opportunity is expressed in several ways. Teaching loads must be moderate for the person who is to do creative work. The able young fellow with a provocative idea (or the older fellow, if he has one) needs support in the form of time, facilities, and usually a little money. These needs are normally modest, especially in the early stages of a project. Personal encourage-

ment and academic recognition are powerful.

This encouragement may have the appearance of special privilege to other members of the faculty, and indeed it is special privilege in terms of the undergraduate teacher carrying a heavy load of standard instruction. But with this special privilege comes a serious obligation to produce good work. The net result is a special responsibility rather than a special privilege.

In making the beginnings of a research activity, the important things are special facilities, a large amount of money, or imposing physical requirements. The vital thing is the able man with the creative spirit and the encouragement to him to do original work. This leads normally to interesting new results, to publication and getting known in the profession, and perhaps most important, to sharing with students an experience of exploration into new problems. Financial support for such work can often be obtained after a man has demonstrated himself to be productive.

Quality is Important

In such creative work, quality is very important, for this work enters competition for recognition on the national rather than the local scale. Such quality requires imagination, independent thinking and high intellectual standards. Intellectual hobnobbing with the mathematics and physics people is often very profitable, indeed even essential to the engineers doing serious research.

On cannot make good research by arbitrary assignment of faculty people to do it. Men with the native capacity and energy for such an endeavor are indispensable. But tying back to the theme of this meeting, it is just those who have this capacity and energy who can bring to a school the vital quality that inspires students with ideals and ambitions that go beyond routine competence.

How does all this attention to research aid undergraduate education in engineering? On the negative side, it interferes with such education in the minds of those who conceive such education as merely a careful indoctrination in elementary science and the well established—albeit sometimes musty—applications of this science in engineering. It breaks up the comfortable orderly pattern of a faculty community devoted exclusively to this type of teaching. It results in an apparently divided purpose in the professor and takes some of his time from his students and teaching. There is a measure of truth in all of these negative points, especially when one looks at them with a restricted outlook.

But the all-important point is that the opportunity to do some creative work amid congenial surroundings is one requisite for attracting vigorous, productive minds to teaching. This is the important idea, because great teaching results from the association between responsive students and able, scholarly and productive faculty.

One frequently hears that the researcher is not interested in students and neglects his teaching and at best gives his students desultory effort and attention. True there are such men, plenty of them, but the place for such a man is in the research laboratory of industry or the research institute; he is not the man for undergraduate teaching, at least of the usual sort.

There are people, however, and their number is not as small as many think, who find the life combining a substantial amount of good teaching and association with undergraduate students with reasonable opportunity to do original work to be a very attractive and rewarding type of life. If in addition some opportunity is included for graduate teaching and association with graduate research, the combination becomes very appealing to many able persons. I would emphasize again that the highest type of undergraduate teaching can be done only in an atmosphere that feels the strong influence of the creative men about whom we have been talking. If an institution has a good sprinkling of

these and they are given good support by the administration, the whole tone and stature of the institution are raised above that attainable with an undergraduate-teaching-only faculty.

There are, of course, other contributions made by good research activity in a school. It catalyzes the association of the faculty with others in the profession. It breaks through the ivory-tower isolation and makes the faculty members actual participants in the professional engineering world. This brings to the faculty and thus to the students the spirit of fresh thinking on new problems and courage to venture into new and unfamiliar areas. It leads to projects by which able students experience glimpses beyond present practice into future possibilities.

Closer Relations with Industry

Faculty research can also add to closer relations with industry. Many of us here who are still far from retirement recall the period when industry at large regarded as suspect—or perhaps more frequently ignored completely—the amusing but harmless ideas of the professor-researcher. There are some such industries today, but there are far more that think differently. These latter have seen enough examples of older industries being superceded as the result of some supposedly idle research to make them keep an eye to windward against a change in technological weather that may necessitate their changing course on short notice. Thus the area of common interest between forward-looking industry and the scientific or technological school engaged in even modest but good research has increased clearly in the last decade or two. The corresponding increase in interchange of ideas has been healthy for the schools, for industry, and for undergraduates.

Research activity in the engineering school inevitably gets the undergraduate program away from the flavor of 20 or 30 years ago, away from the back-country atmosphere where the model T is still regarded as modern transportation. Not that I would disparage the charms of the back-country. But when we are up in the back-country we wish to enjoy it for what it is and not delude ourselves into thinking of it as the modern industrial world.

I would not have the remarks of this paper berate the dedicated professor whose life work has been to lead generations of undergraduates toward wisdom and warm human experience as well as to teach elementary structures or thermodynamics. He has his place in the scheme of things and a worthy place. But the technological and scientific character of our time requires that he who would be a part of it should come under the influence as well of the dynamic, imaginative, scientific-minded teacher who is himself an integral part of the swiftly moving stream of technological advance.

Fundamental Research from Standpoint of Industry *

By CARL F. PRUTTON

Vice President, Mathison Chemical Corporation

I am speaking to you today as an individual, and not as a representative of my employers or of the industry in which I am employed. My experience in industry of several years' full time employment gives me some small qualification for expressing some of industry's attitudes on this subject, but nearly three decades of

* General Session by the Engineering College Research Council, ASEE, June 24, 1953.

service in engineering education I believe qualifies me to speak with some justification on the subject under discussion. I will try to convey to you my ideas on the attitude industry has toward fundamental research in our schools and then how industry could help such a program.

Industry clearly sees several major reasons, from its own self interest, why it should encourage and aid an expanded basic research program in our technological institutions. First, through tremendous expansions during the last thirty years, industry has greatly enlarged its activities in applied research to solve its short-range problems and develop its new products and processes to a point where the accumulated basic scientific and engineering facts and principles available may not be sufficient to render such applied research highly effective. Industrial research laboratories are not the ideal locations for the conduct of this basic long-range research activity. Most industrial research laboratories find it difficult to obtain budgets for these long range fundamental studies which may not pay out for many years, if ever. I have no statistics at hand, but it is my estimate that such expenditures do not exceed five per cent of our U. S. industrial research expenditure. Industrial research has always relied upon the fundamental data and principles which have come largely from our schools and universities, but due to the greatly increased scope of our applied research and due largely to financial restrictions in our schools, this basic information is not being produced at the necessary rate. Although I do not wish to draw a sharp line between scientific and engineering fundamental research, basic investigations in engineering have been a fairly recent development in our schools and manpower involved is much lower than in the scientific fields.

Unless industry establishes separate laboratories for carrying on its fundamental research, it must encourage and aid in expansion of such activities in outside institutions, and as we will see later the only logical place for such work is in our schools of technology. Basic research must be conducted in an atmosphere completely different from the drive toward immediate results and short-range objectives found in industrial research establishments. It must be conducted under conditions where there is a minimum of secrecy and where open discussion of the research with all interested parties may be had. Such open discussions enable the researcher to obtain outside advice as well as to reduce the possibility of too much duplication of effort on the same problem. In industry, due to its secrecy in its applied research, competitive duplication is widespread and in many cases very desirable. In fundamental research the need for secrecy is not as great and since the results are published and discussed freely when the problem is solved, other laboratories are aware of which phases remain to be solved, and can therefore effectively avoid useless duplication of research effort.

The second major advantage industry can see in encouragement of basic research in our engineering schools lies in the improvement, through such greater activity, of faculties and of educational processes which will yield engineering graduates who are better trained for industrial leadership in the years ahead. American industry, and particularly the chemical industry with which I am connected, has since the early 20's become increasingly dependent, for its phenomenal growth and vigor, upon technically trained men. The policies and actions of such leaders in the efficient coordination of scientific, engineering, business and sales personnel into effective and efficient organizations have been the basis of such growth. Industry has recently experienced vast technological changes and as it looks ahead changing technology must be continuously met and problems solved rapidly. To continue its forward march, industry must produce new products and continue improvement and cost reduction on existing products and processes. Enlightened technically

trained leaders must be available in order that industry may meet these new conditions.

New Industrial Atmosphere

The chemical, electrical, electronic, and aircraft industries have led this technological advancement but even the most conservative of our industries has now awakened to the new industrial atmosphere. Inherent in this industrial revolution of the past several decades has been an increasing reliance upon research and development, not only for producing completely new products but also for improvement of manufacturing facilities and manufacturing techniques.

Our industrial managers of the future must fully comprehend the optimum methods for use and integration of research, development and engineering into the fabric of a company's activities, as well as have a knowledge of finance, production and sales matters. American industrial management is faced with the necessity of learning how to apply and effectively utilize large scale research as a major force in meeting the challenges of the future. In some ways the problem faced is similar to that which confronted allied military leaders in the last war when they had to learn rapidly the technique of utilizing airpower and armored ground units with conventional troops to meet the challenges of the new type of mobile warfare.

We will need in industry in increasing numbers technically trained manpower of highest quality for major responsibilities in management and in direction of research, engineering and other major divisions of industrial activity. Therefore, it is of vital importance that our technological education be fully adequate to meet these needs. Even in the fields of sales and production we must demand leaders who are research conscious, who have a full appreciation of the need for new products and new processes, and who will give fullest cooperation and aid in advancing these necessary industrial objectives. A sales production manager who does not welcome the opportunity of selling or manufacturing a new product, even with the inevitable hard work and difficulties involved, will retard the progress of his company. In the ranks of our research and engineering departments we are in particular need of men looking for new things instead of resisting change. Each member of the management team must fully comprehend and give efficient wholehearted support to this forward moving program in industry.

Higher education and particularly engineering education has therefore a tremendous challenge to modify where necessary its training from a memorization of past engineering methods and practices to adequate training in principles and practices which will prepare its graduates for effective careers in industry where change and improvement is the order of the day and past practices are discarded when superseded by better methods.

Education in engineering as in other fields is largely a matter of teacher and student, and deans, executive offices, fine buildings and campuses are secondary adjuncts. Without capable forward thinking and acting teachers, capable of original and independent thought, it is useless to hope that the students they train will develop these desirable qualities and thus be adequately prepared to meet the challenging industrial needs of tomorrow.

Qualities of an Ideal Engineering Teacher

During my many years in the teaching profession I have at many times attempted to define the characteristics and qualities the ideal engineering teacher should possess. By such definition I hoped at least to keep from making major errors in my own development, even though I realized that neither I nor any other teacher could meet in a superlative degree all of these requirements. At least this listing gave me a proper humility in my daily work.

First, he must possess a reasonably high intelligence and an active knowledge of his engineering field.

Second, he must have a full determination and desire to dedicate his life to the service of young men, their training for life and for active and creative careers. He must desire to reap his rewards largely through reflected credit from the achievements and qualities of his students. He must feel that through such activities his service to mankind is greatly multiplied by the productivity of his students. That in such dedication of his services to the best interest of the world, his rewards would be within himself rather than the greater honors and economic return he could enjoy in other occupations.

Third, he must not consider his students as a group, but feel a responsibility of bringing about in each individual the maximum development possible.

Fourth, he must perfect the educational techniques of the classroom, lecture room, and laboratory to a high degree.

Fifth, he must possess and be able to transmit to his students the desire and ability to attack and solve new problems. Keeping abreast with developments and planning in industry and education is a necessary activity in this field.

Sixth, he must develop a full appreciation of the psychology of young men and learn those techniques by which one could lead, inspire, guide, and direct when necessary, to develop in them those traits needed in their activities in later life.

Seventh, since courage and the ability to think and act independently are two very important traits of character to be transferred, he must himself not become a subservient individual whipped about by the regulations, administrative departments or red tape of a regimented educational organization.

Eighth, as a teacher of technology he must be completely unbiased, honest and fair in all of his dealings whether it be with scientific data, with individuals, with groups, or with new theories.

Ninth, he must develop in himself and transfer through his example and his teaching certain additional traits:

1. Industry, without which men of major abilities may become failures, and with which men of lesser attainments may reach great achievements.
2. Consideration of others, including the concepts of tolerance and charity.
3. A realization of the tremendous opportunities under our American system which, although it can be improved, is by far the best system yet devised by man.
4. Full appreciation of the cultural and religious aspects of living.
5. Patience and persistence in attacking problems and in dealing with individuals. Patience to employ modified repetition successfully in educational processes, a method which is essential in all types of teaching.

Teachers who maintain a reasonable and balanced research program or who maintain contact with active industrial research are more apt to have these leadership and teaching qualities than are those who confine their teaching to classroom activities alone. Although we need in our schools skilled teachers and lecturers who do not engage in research activities in certain fields of education, they must be kept to reasonably low numbers if engineering education is to be fully effective. At present, there is still too great a reliance by engineering teachers upon ultraconservative engineering practices proven by many years of use and a firm resistance against new methods. Too often engineering courses are taught by men of faint imagination and ambition who resist the use of mathematics and science and who in their teaching force upon their students a blind memorization of formulae and acceptance of technical dogma. Very seldom will you find these traits in a faculty member who is conducting original research in his field.

Industry Vitally Interested

Industry is therefore vitally interested in the training of its future leaders and

believes that more fundamental research in the schools should aid in obtaining the type of teacher required, a high type of student, and an improved training of these better students to supply the forward looking industrial leaders of tomorrow.

Another reason for industry's support of expansion of fundamental research in our educational institutions is to decrease the likelihood of this function being taken over completely by the Federal Government with its many possible evils of Governmental control.

With greatly increased research activities by our Federal Government and the urgent need of research in our engineering schools, there is the possibility of direct or indirect control by politicians of our entire advanced educational system. This could have disastrous effects on both education and industry.

I do not have data at hand to give comparative dollar volume of educational budgets and research project budgets sponsored by the Government, but in many schools they are of similar magnitudes. Many educational institutions are quite sensitive to sums of money paid as overhead on research contracts, a subject which I do not have time today to discuss.

Any client who pays half of one's budget must be at least listened to with respect. The widespread support of research programs by many industries would greatly eliminate the chances of directive control by any group.

Teaching contracts or agreements for senior faculty members are always on a minimum term of one-year employment; therefore the uncertainty of receipt of Government contracts and the working under Letters of Intent create an unwholesome atmosphere for the campus. It is my hope that when industry does aid research in our schools, it will do so in grants covering three or more years to avoid these perpetual crises which are disturbing to educational personnel.

I have confined my comments to fundamental research since it is my opinion that applied short-range research does not mix well with academic procedures. Short-range research requires quick actions and quick results and does not brook interference from other activities. In an educational institution, *education* must come first and cannot be interfered with. Therefore I feel that if and when applied research is to be conducted, it should be handled by full time personnel in special laboratories or as in some schools by research foundations.

Major Interests

To summarize, industry has several major interests in promoting fundamental research activities in technical schools.

1. To build up our stock of fundamental knowledge in science and engineering so the applied research and engineering programs in industry may continue on on efficient expanding basis.
2. To improve training of technical students for management assignments in industry.
3. To make more diffuse the assistance received by technical institutions in order to prevent the possibility of complete monopoly by any organization outside of the university itself.
4. To improve its relationship with colleges and therefore receive more thoughtful consideration when graduating students seek employment.

Now let us consider if industry will be permitted to help and under what conditions and finally in what forms this help may be extended. In many of our states, laws of incorporation prevent contributions to educational activities of this type. Stockholders may also bring legal action to restrict such contributions. It is hoped that through test cases a more liberal policy may be adopted. In general, surveys have shown that stockholders are not averse to such contributions, but a minority if opposed could make such contributions very difficult. If and when major contributions may be made, it is quite certain that industry will establish effective means of distributing assistance where it

will do the most good. Even for present day limited assistance, such care is exercised.

Judge A. A. Stein, of the New Jersey Superior Court, recently handed down an important decision on the right of directors of a company to make contributions to educational institutions. Judge Stein gave a splendid exposition of not only the *right* of corporations to make such contributions, but also their *obligation* to do so. It is expected that further court decisions of this type may relieve Boards of Directors of their apprehension in making contributions for educational needs.

The methods of assistance which industry may employ vary widely and include:

1. Contributions on an annual basis to either a general unrestricted research fund for an institution, a department or even a teacher, which the school may use as it sees fit in research activities, laboratories, equipment, etc.

2. Contributions toward a worthwhile educational objective, connected with fundamental research, for example:

(a) Research Fellowships for fundamental research
(b) Establishment of research professorships
(c) Assistance in establishing needed educational and fundamental research divisions
(d) Sabbatical years for research men from industry

3. Loan of research equipment or reciprocal use arrangements with school.

All such actions will bring closer understanding between colleges and industry and in so doing will strengthen both.

Fundamental Research from the Viewpoint of the Private Foundation*

By JOSEPH W. BARKER
President Research Corp., New York City

It would be difficult to point out a period in the history of engineering education in the United States when the question of fundamental research was more pressing than it is today. How is it possible to make such a statement when the total volume of research in our educational institutions is at an extremely high level—possibly at an all-time peak? Why is the American Society for Engineering Education devoting an entire session to this subject when research is being so amply supported? Why are we worried and have we real reason for our worries?

I believe we have real and urgent reasons for our worries. Could we cast up a consolidated budget for all our engineering institutions, I believe we would find that research expenditures are accounting for about one third of our total expenditures. In discussing this point for *all* educational institutions, the Commission on Financing Higher Education on page 355 reported, "The total expenditures of higher education for *organized* (italics mine) research activities in 1950 amounted to $222,000,000 (of this $132,000,000 was government contract research). Thus, contract research was about 60 per cent of this total. If we add other federal funds for agricultural and medical research, we find that the federal government provided about 70 per cent of all income used to support this part of the work of higher education." Two

* Address given at the 61st Annual Meeting of the ASEE at the University of Florida, June 24, 1953.

points must be taken into account in evaluating this for our engineering schools. The first point is that the Commission is speaking of *all* higher education, and it seems obvious that proportionately higher relative amounts would prevail in the engineering and associated science departments of our engineering schools than in *all* higher education. And the second point is that the Commission included departmental and institutionally supported research under their accounting heading "Departmental Instruction and Research." What the proportion of those expenditures was for research is anybody's guess, and in our engineering school budgets, this research item under "Departmental Instruction and Research" will run proportionately higher than in *all* higher education.

Any such budgetary imbalance bodes trouble for our schools. Research, and I am at this point not differentiating between pure, applied, and development research, has become too large a proportion of our consolidated expense budget for any degree of comfort to our administrators. An additional cause for worry is the preponderance of government contract research in this total amount of research. Such contracts are dependent upon Congressional appropriations from year to year. There is and can be no assurance of continuity. All of us have had experience with sudden terminations due to lack of appropriations with all the sad effects not only on our financial commitments but also on staff morale.

Problem is Acute

This problem is peculiarly acute for our smaller institutions and without naming the school let me cite just one example. In March of 1953 President X wrote me that he needed to be able to assure the fourth man in one of his engineering departments of re-appointment for the coming scholastic year. The department has a teaching load requiring the full time of three and one-half men. The fourth man has spent approximately one half of his time supervising a government research project of fundamental character. I quote from President X's letter:

"The trouble is that we shall not get an answer from ONR until June or July and that is too late for a definite commitment to Professor Y. For his sake we need to fish or cut bait at this particular time. My request to Research Corporation is for a contingent grant of Z dollars which would be used in the event that ONR turns us down, but which would be cancelled if ONR sponsors this research."

to which I replied on March 5:

"Immediately upon receipt of your letter of March 3 relating to Professor Y's research project, I discussed it with our Division of Grants. We feel definitely that this falls without the realm in which we usually operate for precisely the reasons I outlined to you over the telephone. However, all of us agree that your problem is most pressing and since our Board of Directors has placed a small fund at my disposal for emergency and non-precedent forming experimental grants, our Grants Division agrees with me that it would be highly effective for me to make this grant from that fund. Consequently, I am enclosing our check drawn to the order of (your) college in the sum of Z dollars to be used for the purposes outlined in Professor Y's letter to you of February 28 and enclosed with your letter to me of March 3."

On March 9 President X wrote:

"We shall bank the check of Research Corporation and hold this sum pending the decision of ONR. If this comes through, we shall return the Z dollars to you—if not, we shall use it as outlined. I cannot tell you how pleased I am by this action which solves a very real problem for us. . . ."

In amplification of my letter of March 5, I wrote President X on March 12 as follows:

". . . I want to amplify that letter and strengthen what I had told you on the 'phone of our policy on grants.

"We have consistently denied applications for grants which contained in their budget any provision for payment of a stipend to a regularly appointed staff member. Our reasons fall under two general

headings. First, we consider our grants to be a provision for helping the research project in which the college is primarily interested as being a part of their educational program. If the college is not sufficiently interested in the project to make the time of their staff member available to conduct or direct the research, then we feel the project is not one for us to consider supporting. We never want a project supported by our grant to be pushing the institution into an area of work not consistent with their fundamental educational policy. Second, if we permitted charging the stipend or any part of the stipend of a regular staff member to the project, then we would put the college in the position of 'leaning on our grant as a crutch' to supplement their regular budget. When we had to refuse a continuation of the grant we would be placing the college in a difficult financial situation. But we must move our grants' help from institution to institution, considering them as catalysts to start the 'research spirit reaction' going, then moving to another, then another, etc. We have roughly $500,000 available annually for grants, and if we are to maximize our help to education in general, we cannot keep any sum constantly available to any one institution.

"I trust you see the general validity of our policy and I believe you will agree with its basic philosophy.

"Fortunately, our Board of Directors has shown its confidence in me by making a sum available to me as a 'President's Fund' to permit me to do 'experimenting' without setting precedents for our general policy. It seemed to me and to our Grants Division that this case was one worthy of 'experimentation,' so I made the grant chargeable to my fund. If you do not get the ONR contract, then I will have used up about one-third of my kitty for this year. But I was glad to be able to help you solve your emergency problem without casting overboard our general policy."

On June 1 President X wrote me as follows:

"We have just had final word from the Office of Naval Research regarding the proposal about which I wrote you some time ago. From conversation and previous correspondence we have the strong impression that this negative decision was reached as a result of the present economy mood of Congress combined with the fact that the research program is much more in the territory of basic research than of applied research.

"This means that we shall not be able to return to the Research Corporation your check for Z dollars which you sent in response to my contingent request. I am disappointed in this regard, for we had all been quite hopeful that ONR would come through. We shall keep you informed of the progress of the research, and Professor Y will file whatever reports you would like to have. Once again on behalf of the college I send you and the Research Corporation our warm thanks for your help."

On June 3 I wrote Professor Y as follows:

"I am sorry for your college that you received the negative reply from ONR on Professor Y's project. Our help simply postpones your staff problem for one year, as I see it. We are, however, glad we could be of assistance in the emergency.

"As to reports we ask only the very simplest. When Professor Y closes his project in June 1954, we would like to have:

(a) From your Treasurer or Comptroller a financial report showing how much was spent from our grant for—

1. Equipment
2. Salaries
3. Expendable supplies, machine shop work, etc.

(b) From Professor Y a brief report showing what scientific accomplishments were produced during the year and, if results are published, where, with two copies of the publication for our files.

"It has always been our policy not to require any detailed reports either financial or scientific. If the man and the institution are good enough for us to support, we expect they will treat our grant as if it came from their own endowment income. We want no vouchered accounting, we want no detailed research reports—we want to *help* not to complicate the college's problems."

On June 9 President X replied:

"I don't know when I have received a nicer letter than yours of June 3. We shall

provide the very simple reports you ask for, and I can assure you that these do not complicate our institutional life! Thank you not only for your help, but also for your understanding."

To have quoted all this has taken time, but I think it illustrates most clearly several phases of the question before us—the problems of a small college arising from contract research; what happens when a professor's stipend and tenure become dependent on a contract renewal (or for that matter on a foundation grant), and lastly how a private-enterprise foundation can help a college in an emergency. Incidentally, it also emphasizes our Research Corporation philosophy of grants-in-aid of research. Parenthetically, I want also to emphasize that this action on our part was a *nonprecedent*—I would hate to have a flood of similar requests; I simply couldn't handle them as I did this one.

Another cause of our worries about research beyond the mere budgetary imbalance and the uncertainties of contract research support, arises from the very nature of the vast majority of research projects in our engineering schools. Because engineering is Applied Science, the natural tendency is toward applied or development research, thus leaving the vast majority of basic research to our science colleagues. But there is a real area of basic research in strictly engineering problems which should be undertaken by our engineering staffs. Here, it seems to me, is a real vacuum at the present time.

Contract Research

Contract research, particularly from the Defense Department, is and properly should be largely in the field of aplications and developments, dedicated to better weapons, etc., for defense of our country. Much, but fortunately not all, research conducted for industry in our engineering schools is also applicatory or developmental in character. If these projects crowd our engineering school research facilities and engage the major attention of our engineering faculties, there is little room for basic engineering research, which ought to be the primary objective in our schools.

From our experiences in Research Corporation over the past eight years of my presidency, we note other tendencies in the engineering projects submitted to us for possible support. First, "coefficient evaluation" seems to rank high in our engineering colleagues' minds as basic research. While we recognize the need for such routine investigations to improve our design formulas, I must admit such projects leave us cold and receive scant support from our Advisory Committee. They smack of "cook-book research" necessary to "improve the cake but hardly contributing to a better diet." Were bachelors' theses projects a requirement in our curricula and were these "coefficient evaluation" projects designed to support such work with a part-time scholarship to the seniors, I think they would receive more consideration at our hands. But as proposals for faculty research, assisted by graduate students, they hardly seem to contribute either to that "inspiration for better teaching" or to the "advancement of our knowledge of the unknown" which we believe are the essential aims of research in our colleges.

The second tendency we note in the projects submitted to us is the proposed purchase of large scale expensive equipment and instrumentation. It seems that we have forgotten how to conduct any experiments in basic areas with ordinary or improvised equipment and instrumentation. Of course the non-linear effect of scale factor is frequently large when we pass from ordinary laboratory to full size commercial equipment, yet it would seem that fundamental research could be at least originated and preliminarily investigated on a small scale with improvised instrumentation. Yet we find grant requests in engineering areas running from two thirds to three quarters of the original budget for "new equipment and instruments."

The third tendency we note revolves around "patent consciousness." This

seems to have been on the continual rise since 1946 and we believe is thoroughly detrimental to a proper faculty research attitude. This may be true for Research Corporation and not for other foundations because of our mutual agreements with many colleges for the handling by us of possible patents arising from staff research. We notice (or think we do) an apologetic attitude on the part of some engineering applicants saying for instance, "there seems, however, to be small probability of anything patentable arising from this proposed research project." Let me say as clearly and as positively as I can that any anticipated lack of potential patentability is absolutely *no* drawback, and conversely that undue attention to patentability *is* a drawback to our making grants. Research Corporation grants-in-aid of research are given to support extensions of scientific knowledge and for that purpose alone. In this connection also I ask that you remember the statement of our fundamental philosophy on grants which was contained in my letter to President X of March 12. It is so basic to our thinking that I will reread it.

Patents have an important place in our free-enterprise economic system. They offer a necessary and desirable incentive to creative invention and they offer the necessary and desirable protection to permit and encourage proper economic exploitation. *But* they should be and must be kept as the secondary aspect of college research. They, as well as contract research, must not become the tail that wags the dog.

With the exception I will cite later (when Research Corporation asks the institution and some staff member to undertake specific research) every Research Corporation grant is given with the full understanding that no patent strings are attached. The results of the research program are to be published for the information of all, and if any patent possibility should arise from the work, the patent is the property of the staff member and his institution. I cannot emphasize this too strongly for I hear occasionally from colleagues that they understand we claim all patent rights. This is just *not so*—we *disclaim* any rights whatsoever.

Patents from Staff Research

The obvious reason for this misunderstanding arises from the fact that many colleges have turned to us for help in handling patents arising from staff research. We have general patent management agreements with some 50 colleges under which the patents, if issued, are assigned to us and royalties are divided in agreed upon percentages between the staff member, the institution and us. After our expenses of administering these patents are met, our share can go only for the support of research since we are a foundation and have no stockholders.

There is one exception to the statement I made a moment ago, "Research Corporation grants-in-aid of research are given to support extensions of scientific knowledge and for that purpose alone." This exception is also contained in recent comments I made on the Preliminary Report of the Committee on Institutional Research Policy of the American Council on Education.

This Preliminary Report states five fundamental principles:

"1. All accredited institutions of higher learning subscribe with varying emphases to three primary and essential aims: (a) the *extension* of the boundaries of knowledge; (b) the *conservation* of knowledge already acquired; and (c) the *diffusion* of knowledge through sound teaching and other accepted methods of dissemination.

"2. A college or university may and usually does have additional objectives deriving from its character as a society of scholars, which may lead to other public services, but should do so to the extent that such service is compatible with its primary aims.

"3. The extension of the boundaries of human knowledge is accomplished primarily through basic research. The results of such research are made available through publication to the entire scholarly community; their validity is appraised through criticism and reexamination by competent colleagues.

"4. Applied research is necessary to human welfare. In an institution of higher

learning, however, it is particularly valuable if it tests the results, or stimulates the progress of basic research, or assists in the training of younger men and women, who must in the future carry on the research program.

"5. Classified research, which contravenes the diffusion of knowledge, is justified in a college or university only as a public service in emergency conditions because its faculty constitutes a society of scholars who have special competence in the given fields, and it should continue only so long and so far as the emergency conditions exist."

The Preliminary Report goes on to state under "Title III—Suggestions and Recommendations to Colleges and Universities," paragraph 5:

"The educational institution should carefully determine the entire cost to it of sponsored research, and if it accepts contracts that do not cover both direct and indirect costs, the institution should do so with the full recognition that it is itself making a contribution to the cost of the work. The present program of vast research expenditures on the part of the government could do serious damage to the economies of our colleges and universities if handled largely on a grant-in-aid basis without provision for indirect costs. The Committee believes that this is a part of a larger problem facing our colleges and universities, involving the acceptance of grants-in-aid from those foundations and other sources which at present do not pay the full cost of the projects they support."

Again under "Title VI—Sponsored Research and Foundations," paragraphs 1, 2 and 3 read:

"1. The Committee recognizes the great contributions which foundations have made through the grant-in-aid support of basic research, particularly the help they have given in 'grub-staking' new ideas and projects.

"2. While such grants-in-aid must continue to play an important part in the financing of research, the Committee feels that educational institutions should be mindful of the financial hazards involved in the uncontrolled acceptance of grants-in-aid which do not cover all costs. An institution can bankrupt itself by failing to recognize the cost of projects so financed.

"3. The Committee urges both educational institutions and foundations to review their policies with respect to grants-in-aid, giving particular attention to the need for provision for indirect costs in large grants. It sees much encouragement in the fact that a few foundations already have made grants which covered indirect as well as direct costs."

President Adams of the American Council on Education sent a copy to me saying:

". . . I would be glad indeed to have any comments which you may wish to make on this report.

"As the title indicates this report in no sense is to be considered as final conclusions but is meant to be provocative of comment and discussion. So far as we can determine it has certainly succeeded in these aims!"

I want to read my reply because it together with my statement of our philosophy of grants emphasized above puts our Research Corporation policy on record.

"The five 'fundamental principles' are excellent—no one could take *any* exception to them. *But* they are also the 'fundamental principles' of foundations such as ours established to further science. Yet, again and again throughout the balance of the report there is a tendency to lump 'foundations' with government, industry, etc. as causing financial problems to the colleges unless 'overhead' is charged on grants-in-aid. To this I take real exception.

"In fact, it would be only a very short step from the expressed philosophy of this report to say that the institution should charge 'Alumni Funds' with institutional 'operating overhead' because the Alumni Funds cause the institution to assume 'overhead' charges to expand their educational and/or research program as well as the 'overhead' of the Alumni Fund drive itself.

Overhead Charge

"Where my personal philosophy departs from theirs rests on the following point. *If* any outside organization—government, industrial or foundation—*asks* the institution to undertake a new, or revised, or enlarged function of education and/or research *then* a proper overhead charge seems justi-

fied and reasonable. Where, however, the *institution proposes* a program to the government, industry, or foundation for support, and where the proposed program is a proper element of already established areas, in which the institution is already active, then the inclusion of institution overhead becomes questionable. Should the institutionally proposed program be a large one which obviously would require considerably expanded costs, then I think the institution is justified in asking to include the additional overhead in its proposal. Where, however, the institutionally proposed program does not require increased overhead costs, I see little or no justification for asking the grantor to include a flat per cent overhead charge in its 'grant-in-aid.'

"Let me illustrate by two typical cases pertaining to Research Corporation. Professor X of Y College prepares a research project which is a part of the general activity of his department; he submits it to his Dean or President for approval before transmitting it to our Grants Division for consideration. His proposed budget may include (a) special equipment (or modification of existing equipment) needed to conduct the particular project; (b) supplies and expendable materials required; and (c) assistance (or fellowships) to help him prosecute the research. This is just the same as Professor X would propose were the project to be supported out of the institution's own research appropriations. In fact, if we make the grant-in-aid, our funds are simply *easing* the load on the institution's own expense budget—we take over that on which the institution would otherwise spend its own income. We even transmit the entire year's grant *in advance* with our approval of the project so that not only does the institution not have to use any of its funds (against later reimbursement) but actually has the use of our funds months in advance of its cash outlays on the project. *And* whatever instrumentation is purchased from the grant becomes the permanent property of the institution, publication is not only permitted but almost required and no patent strings are attached. How can any 'overhead' be justified by any stretch of the imagination?

"The second type is where Research Corporation asks Y College and their Professor X to undertake a specified research. For instance, when Dr. Kendall working under a grant-in-aid from us to the Mayo Foundation, and aided by Merck & Co. both by intermediates and Dr. Sarett's researches in Merck's laboratories, synthesized Cortisone from ox bile, it was apparent from the original efficiency of the approximate 36-step process that all the available ox bile in the world would not produce enough Cortisone to meet the then anticipated needs for treating arthritis. We *asked* Dr. Woodward at Harvard, among many others in other colleges, to drop what research he was then doing in the steroid field and undertake the 'complete' synthesis from some starter material in ample supply at low cost. *Now* Harvard would have been justified in asking Research Corporation, even though we are a foundation, to include in the budget for support of Dr. Woodward's research an item of institutional overhead. (Harvard didn't do so but that is beyond the point.) *We* were asking *them* to drop at least part of what Dr. Woodward was doing and to have him do something for us—to be sure for the suffering world also. We would have been willing to include a reasonable institutional overhead in the grant. These two cases illustrate where I think the dividing line can most reasonably be drawn."

This second type of research grant—where Research Corporation asks an institution and a member of its staff to undertake research on or development of a specific problem of vital interest to us because of our financial interest in a patent, is the one type in which we ask that any patents flowing from this later research or development shall come to us also for management with the basic patent. Of course, both the institution and the staff members associated with this later program would share in due proportion with the original inventor and his institution in the combined royalties, should applicable patents flow from their research or development. I must add, however, that this type of grant is a very unusual one with us and arises only occasionally.

Summary

To sum up then, I believe that the "Five Fundamental Principles" of the ACE Preliminary Report should become the guide signs for our institutions in con-

sidering the problems of research. I believe that we must press as rapidly as world conditions permit to a rational balance between contract applied or development research and basic research. I believe each institution must make a self-evaluation of just how much research it has the equipment, space, and staff to conduct and how much it can afford to permit being conducted within its walls. I believe research and teaching must be a balanced ration.

I believe that our educational institutions must press for adjustments in the personal and coporate income tax laws. The flow of gifts to endowments has not been great enough to overcome the reduction in interest rate on invested endowments, to cover the decrease in the purchasing value of the dollar, to cover the increased student load on the institutions, and to leave a sufficient margin over the purely instructional costs to permit adequate research support. To continue to accept classified government contract research beyond the "public service in emergency conditions" as a means of carrying institutional overhead would be just as bad as accepting outright government subvention of education.

The institution must remain the "major partner." It must be prepared to accept or not to accept contract research of any description whenever, except in "emergency conditions," it believes the long range best interests of education will be best served thereby. Financial freedom is just as important as Academic Freedom.

And finally, our institutions should look principally to our private enterprise foundations for support in "grub staking" new ideas and projects as so excellently stated by the ACE Preliminary Report. To this I would add in catalysing the research to a point where the institution can secure public support for continuation of the work. Foundation support through grants-in-aid should be a supplement to research appropriations from endowment income and not a crutch with which the institution limps through one of its "three primary and essential aims—the extension of the boundaries of knowledge" to quote again from the ACE Report.

It would be fatal to the proper research attitude in our educational institutions if all research were supported by either government, industry, or foundations. The institutions must be free of even that modicum of control which comes from submitting for support their research projects to outside agencies, even eleemosynary foundations. And the greatest danger of all would be to have only one agency from which outside support could be sought. That is the certain road to loss of freedom.

College Notes

Dr. Gaylord P. Harnwell has been elected President of the **University of Pennsylvania.** As President, he will succeed Harold E. Stassen, who resigned January 19 to become Director of the Mutual Security Agency. Since that time, William H. Du Barry, Executive Vice President, has been Acting President.

* * *

Kurt F. Wendt, Professor of Mechanics and since 1948 Associate Director of the Wisconsin Engineering Experiment Station, has been named Dean of the **University of Wisconsin** College of Engineering by the UW Board of Regents. Wendt succeeds Dean Morton O. Withey who retired July 1. The regents also named Prof. William R. Marshall Jr., now Associate Professor of Chemical Engineering, Associate Dean of the College of Engineering and Associate Director of the Wisconsin Engineering Experiment Station.

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Report from the Committee on Society Finances of ASEE

The following report of the ASEE Committee on Society Finances with respect to individual dues was adopted by the General Council on June 26, 1953, with the recommendation that it be published in the JOURNAL and that a letter ballot be mailed to the Society membership.

To: The Members of the Society

Gentlemen:

Your committee has been exceptionally busy for a considerable time examining into and studying carefully the accounts of income and expense of the Society. It became evident quite early that the ASEE would soon be facing a serious situation. It is estimated that as of June 30 this year the deficit would exceed $1000. When we considered next year's budget and pared it down to what we considered to be the bare minimum of operating expense, the deficit would be about $4000. The Society does have a reserve, but we recommend against any reliance on this reserve for future use.

A thorough examination of the dues structure reveals the following. Up to 1929 dues were $4.00 for individual members; in 1929 the dues were raised to $5.00 and in 1946, when the name was changed to American Society for Engineering Education, the dues were fixed at $5.50 for librarians and grades under associate professor; $6.00 for associate professor and $7.00 for all others. It is estimated that the average dues for the entire Society from individual members is approximately $6.25. You will note therefore that there has been an increase from 1929 to the present time of $1.25. We think you will agree with your Committee that there has been most excellent management of the funds of the Society. Additional funds from advertising in the JOURNAL and the money received from Institutional, Affiliate and Associate members has enabled the Society to function successfully. Your Committee recommends that the steps taken recently to increase the number of Associate members be continued.

We have examined the income, expense and cost of publication budgets for the last eight years. It is worthy of note that in 1944–1945, the cost of publication of the JOURNAL was $9549. In 1952–1953, the cost was $26,459 without any increase in paging. It is further estimated that the cost for the coming year will be approximately $30,000 with little increase in service to the members.

The accompanying graphs are of interest showing the change in income and expense over the years.

As a preliminary statement your Committee suggests two classifications of individual memberships divided according to age and that the age of 35 years be the dividing line. This corresponds to the division for young engineering teachers. The cumbersome method of changing dues according to rank has made for excessive clerical cost and that method has not proven satisfactory and should be abolished.

Your Committee recommends that an increase in individual dues be requested in accordance with Article XI, Section 2 of the Constitution of the Society and further that the By-Laws of the Society be amended in conformity with the wishes of the membership as determined by letter ballot of such membership. Your Committee is of the opinion that the annual

dues should be determined by vote of the General Council of the Society at a regular meeting at which the budget for the following year is also adopted. The dues, however, should not exceed $10.00 per year for members above 35 years of age nor $7.00 per year for those whose age is 35 years or less. Since the fiscal year of ASEE starts on July 1, a member would be eligible for the lower dues rate in a given year if his 36th birthday had not occurred prior to July 1 of that year.

The Committee suggests that the ballot contain the statement that the dues may be adjusted in accordance with the needs of the Society, but not to exceed the above ceilings on recommendation of the Budget Committee and by vote of the General Council of the Society at a regular meeting. For the coming year, 1954–55, it is estimated that the dues would only need to be $6.00 per year for those under 35 years of age and $8.50 per year for those over 35 years.

THORNDIKE SAVILLE
S. C. HOLLISTER
F. M. DAWSON, *Chairman*

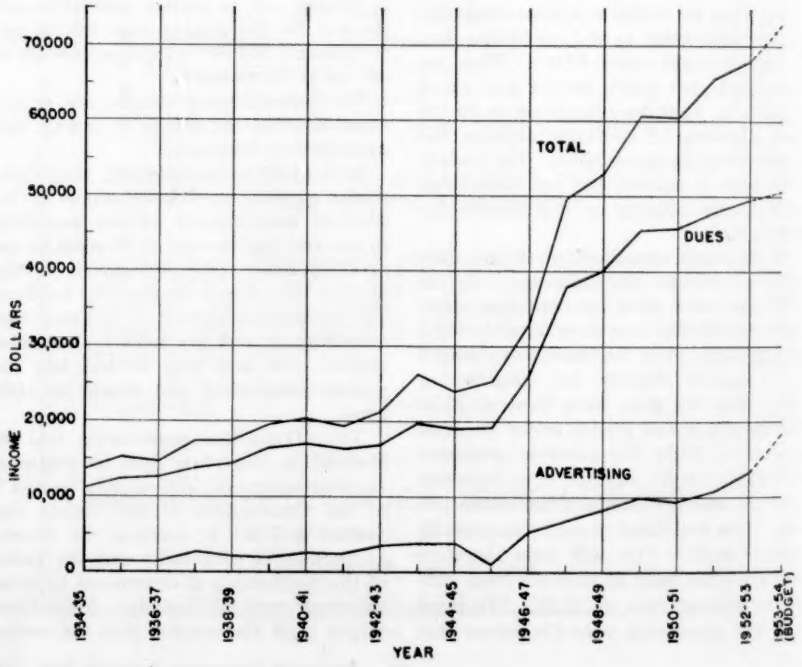
Other Pertinent Society Information

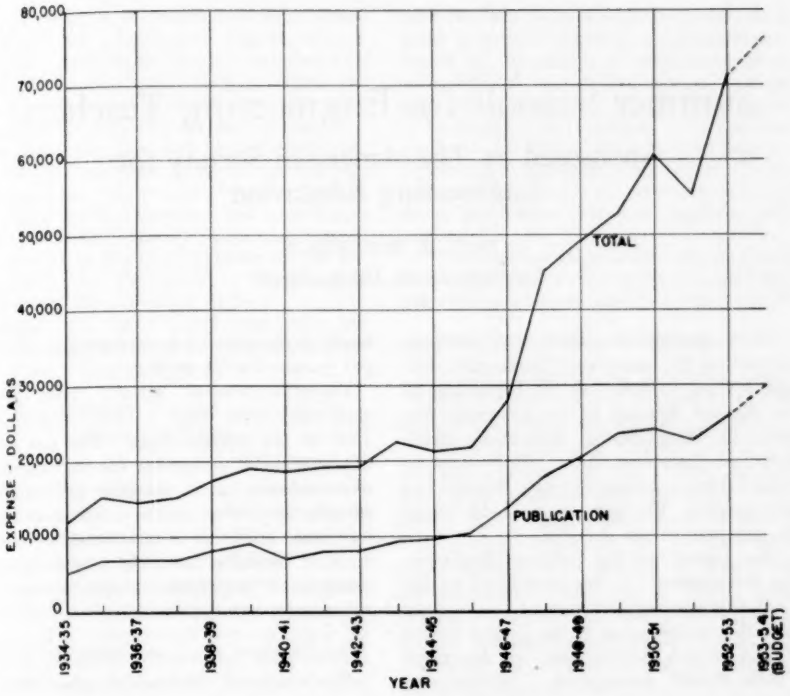
1. The Society membership has approximately doubled since 1945.

2. The cost of operation of the Society per member has been substantially constant since 1945. During this time the cost-of-living index has approximately doubled.

3. ASEE dues per member are about one-third of those of other national engineering societies.

4. In 1945–46 the reorganization of the Society resulted in substantial enlargement. At that time the Engineering College Research Council and Engineering





College Administrative Council were created. The General Council was enlarged and the Society took on new functions.

5. The ASEE headquarters staff now includes five people, a secretary, a part-time editor and three office secretaries. This is equivalent to one staff member for every 1,500 members. Other national engineering societies employ approximately one staff member to every 300 to 400 members. Additional staff is urgently needed, but present finances will not allow staff additions.

6. The ASEE is endeavoring to assume its share of obligation in the Engineers' Council for Professional Development, the Engineers' Joint Council and other organizations coordinating the activities of the engineering and educational professions.

Summer Schools for Engineering Teachers

Sponsored by The American Society for Engineering Education

By B. J. ROBERTSON

Vice President ASEE, 1947–50

Three groups of engineering teachers arrived on the campus of Dartmouth College several days before the beginning of the Annual Meeting of the American Society for Engineering Education which was held there last June. They came to attend three separate Summer Schools for Engineering Teachers to be held under the auspices of the A.S.E.E.

One school was for Sanitary-Engineering Instructors. It was sponsored by the Civil-Engineering Division of the Society with the co-operation of the United States Public Health Service and the American Public Health Association. Another was devoted to the discussion of Teaching Electrical Fields and Circuits to Undergraduates and was sponsored by the Electrical Engineering Division of the Society. Teachers of Engineering English who spent three days discussing the Orientation of the New English Teacher made up the third group.

Did you say unusual!, unique!, how interesting! ? They were interesting for those who attended but are not unusual or unique for members of the A.S.E.E., for such schools or conferences have been operated by the society since 1927. If you read the April 1952 issue of the JOURNAL OF ENGINEERING EDUCATION, you would have noticed that a Summer School for Teachers of Surveying was to be held at the Summer Camp of the University of Illinois located in the Chippewa National Forest near Black Duck, Minnesota. The total cost of sleeping accommodations and meals at this camp was estimated at $25.00 per person for the week.

Society-sponsored schools were held each year from 1927 to 1934 and from 1947 to the present time. The war and the accelerated programs for the veterans overshadowed any thought of summer schools for twelve years. Instructors had no time available for attendance and housing facilities formerly used for summer-schools registrants were in use all summer by regular students.

The Origin of the Summer School Idea

The origin of the summer school movement dates back to the Investigation of Engineering Education made by the Society for the Promotion of Engineering Education, now known as the American Society for Engineering Education. Six years—1923 to 1929—were spent in gathering data for this report which was published in two volumes totaling some 1600 pages. The survey covered schools in the Old World as well as in the New, and Technical Institutes as well as Engineering Colleges.[1]

The director of the investigation, the late W. E. Wickenden, for many years President of the Case School of Applied Sciences, brought back word of the summer schools being conducted in England for teachers in Technical Institutes. Describing these schools, the Report of the Investigation states:

[1] Vol. II, Report of Investigation of Engineering Education, page 244.

. . . "To aid in broadening their educational outlook and to give them the aid of intensive coaching on teaching materials and methods, the National Boards of Education have established summer schools which meet annually for a period of three weeks. . . . The tutors are the most distinguished university Professors of Engineering; and the lecturers, as a rule, are men of special prominence in public, industrial and educational life. While the aims of the summer schools established in the United States by the Society for the Promotion of Engineering Education are somewhat different, the inspiration and the original model for the undertaking must be credited to the schools of Birmingham and Oxford."

The American Version of English Summer Schools

The American version provided schools for faculty members of engineering colleges with no restrictions on attendance except a limitation on the total registration at any one school. Neither college administrations nor Government agencies exercised any authority over them. In England the registrants were selected by the heads of the schools and the National Boards of Education controlled the schools. In America, a seminar type of instruction was advocated with emphasis upon informal personal contact between well-known profesors and humble instructors. Writing in the S.P.E.E. JOURNAL OF ENGINEERING EDUCATION, President Wickenden summarized the objectives as follows:

"A group ought to take some division in the curriculum and explore it, both to survey its content, its new frontiers and to see how it borrows from and contributes to other divisions of study.

"They need to appraise its values to different groups of students, to examine critically the different methods of presentation in use; to work up and try out unit assignments and projects for students and test various methods of measuring the student's progress and attainments; to survey alternate problems of research and to map out programs of original work for themselves.

"Some men in the group ought to be the ablest teachers in the subject, men of mature years to serve as leaders in the group; some ought to present subjects which are closely related to the principal one under study; some ought to be detached enough to make good critics; but most of the group ought to be young men struggling with teaching problems and having the strongest possible incentive for the success of the effort. There ought to be some good teaching, but no sharp distinction between teachers and taught.

"The principal thing however is that they get together and work out the problems systematically, intensely, and enthusiastically."

The First American Schools

The idea appealed to American Engineering Instructors and they went to the Carnegie Corporation for financial aid in establishing Summer Schools for Engineering Teachers in the United States. The Corporation advanced $7500.00. Professor H. P. Hammond—now Dean of Engineering Emeritus at Pennsylvania State College—was placed in charge of the program. This was in 1926. Two schools for teachers of Mechanics were set up for the summer of 1927: one at the University of Wisconsin and one at Cornell University in Ithaca, N. Y.

The subjects discussed were:

A) The Teaching of Analytical or Pure Mechanics.
B) The Teaching of Applied Mechanics in Related Fields.
C) The Exposition of Methods of Teaching in General.

Announcing these schools Dean Hammond said: "The bringing of groups of the ablest and most promising younger teachers into contact with leaders having different points of view and different methods of presentation with adequate opportunity for free discussion promises a forward step in methods of teaching, in developing and holding the interest of the student and putting new life and inspiration into the department of engineering education."

Names well known in the engineering teaching profession were prominent in this first program—Timoshenko, Karapetoff,

Boyd, Poorman, Upton, Leutwiler, Moore. The registration fee was $10.00, room and meals about $15.00 per week. The school ran from 8 A.M. to 12 noon, from 2 P.M. on and again every other evening. One registrant complained that the sessions were so long that there was no time for the recreation planned. He should have realized that this is the rule rather than the exception in engineering meetings. Another wrote: "Enough men for inspiration not enough to make discussion difficult." Another commented: "The lectures from which I got the most profit were those that went somewhat over my head. The result was to increase my determination to increase the distance between my knowledge of the subject and what I try to give the student."

Professor Karapetoff gave a Piano and Cello Concert as a part of the entertainment on one of the free evenings at the University of Wisconsin. Staff and students were housed together; many became fast friends. Forty-one people were enrolled at each of the two schools. About one-third were professors and associate professors, one-third assistant professors and one-third instructors. Twenty-three leaders or lecturers took part, sixty-four institutions were represented.

Growth of the Summer Schools

These two schools were so well thought of that two more were organized the next year, one for teachers of Physics and one for teachers of Electrical Engineering. The schools soon became self supporting; leaders and advisors became so convinced of the value of the contribution to Engineering Education that they donated their time. Some institutions paid all or part of the expenses of their faculty members, perhaps the majority, of the registrants came entirely at their own expense.

It became increasingly difficult to hold the registration down to a point where intimate contact between staff members and students could be maintained. When a new school in a field previously covered was planned, those who attended the first one wanted to come again. They wanted to contact the friends they had made in previous years and to discuss the same questions in the light of additional experience.

Ninety-eight registered at the Mechanical Engineering School at Purdue University in 1929, including three Deans of Engineering. Three days were spent in Chicago where they met men from industry and listened to their ideas on what should be expected of Mechanical-Engineering graduates.

The Civil Engineering Division planned a three-weeks school at Yale University for July 1930. In March there were fifty-two applications and they were unable to keep the final registration below 100.

In 1948 one hundred ninety-nine teachers of Chemical Engineering convened at the University of Wisconsin. Many brought their families to enjoy the Wisconsin lakeside; this brought the total attendance to 396 persons. Yet there seemed to be complete satisfaction on the part of those attending. A large gathering can be effective if some sessions are divided into smaller groups.

When the engineering colleges began to include the Humanities and Social Sciences in their curricula, teachers of these subjects were confronted with new problems. The principal interests of these students were in a different field and the time available too short to allow the effective use of customary material and teaching methods. Interested faculty members and administrators formed the Humanistic-Social Division of the society. In 1950 it held a summer school immediately after the National Meeting at Seattle. A second school was held in connection with the annual meeting of the society at East Lansing, Michigan.

The Integration of the Teaching of Humanistic-Social Studies with the Teaching of Science and Engineering through (1) values and (2) methods of teaching and thinking was the theme of the first school. Courses in Psychology, Economics, Morals and Ethics, Music, etc., designed especially

for engineers and methods of presentation were discussed at the second school. Thus the summer school seems to broaden its scope to keep pace with changes in Engineering Curricula.

The application of fundamental principles to the solution of typical engineering situations has long been an important part of the Advanced Engineering Program provided for its employees by the General Electric Company. Most engineering teachers will admit that their graduates are not able to deal with new situations on their own initiative and from the standpoint of fundamental principles. They will also admit that attempts to overcome this deficiency by college faculties have not been overly successful.

The A.S.E.E. Committee on Improvement in Teaching suggested that the philosophy and methods used by the General Electric Company might be applied by faculty members in some of their regular class work. The company was approached and agreed to conduct a summer school for engineering teachers to demonstrate its approach to the problem.

Registration was limited to twenty-five teachers of either Electrical or Mechanical Engineering between the ages of twenty-five and thirty-five years; Deans of Engineering were asked to nominate one candidate each. Those attending were treated as though they were company employees —were required to do the same evening work etc.—but the course was abbreviated because of the time available. The school was held on the campus of Union College June 16–21, 1952. Registrants were housed in a campus fraternity house; all expenses including travel were paid by the General Electric Company. Thus Industry shows a definite interest helping teachers who wish to improve their technique.

Since the movement started, thirty-one summer schools have been conducted by fourteen divisions, one section and one committee of the society.

Administration Officers
- 1933 University of Wisconsin

Civil Engineering
- 1930 Yale University
- 1952 University of Illinois (Summer Camp)
- 1952 Dartmouth College

Chemical Engineering
- 1931 University of Michigan
- 1939 Pennsylvania State College
- 1948 University of Wisconsin

Committee on Improvement in Teaching
- 1952 Union College (General Electric Company)

Engineering Drawing
- 1930 Carnegie Institute of Technology
- 1934 University of Wisconsin
- 1951 Michigan State College
- 1952 Dartmouth College

Engineering Economics
- 1932 Stevens Institute of Technology
- 1934 Stevens Institute of Technology

Engineering English
- 1932 Ohio State University
- 1952 Dartmouth College

Engineering Mechanics
- 1927 Cornell University
- 1927 University of Wisconsin
- 1950 Iowa State College

Electrical Engineering
- 1928 University of Pittsburgh
- 1952 Dartmouth College

Humanistic-Social
- 1950 University of Washington
- 1951 Michigan State College

Mathematics
- 1931 University of Minnesota

Mechanical Engineering
- 1929 Purdue University
- 1947 Northwestern University
- 1949 Rensselaer Polytechnic Institute

Mining and Metallurgy
- 1933 University of Wisconsin

North-Midwest Section
- 1950 University of Minnesota

Physics
- 1928 Massachusetts Institute of Technology

Thermodynamics
- 1951 Michigan State College

The following reports were received on Summer Schools held last summer:

The Industrial Engineering Division held its first Summer School for Industrial Engineering teachers prior to the annual meeting at Gainesville, Florida, in 1953. The theme for the school was "Quantitative Measures in Industrial Engineering." Eleven speakers presented concentrated reports on the recent developments in and the applications of quantitative measures to industrial engineering problems. Each speaker confined his report to a specific subject area.

Thirty-three industrial engineering teachers and industrialists registered for the summer school. The attendance represented a good cross-section of the nation, both in geography and in interests. Those in attendance participated wholeheartedly in the discussions following each paper. It was more difficult to stop the discussions than to initiate them. Interest was high, and the exchange of ideas was undoubtedly of great value to those in attendance.

Comments following the summer school session indicate that those in attendance generally considered the session worthwhile and a success. In addition to being brought up to date on research and developments, the attendants engaged in a critical self-analysis and self-appraisal which will lead to more unified concepts of the profession. Objectives of industrial engineering education were defined and analyzed, which can only lead to improvement in course offerings.

For the second consecutive year, the ASEE and the General Electric Company jointly sponsored a seminar on teaching methods. This seminar was held June 15 to 20 on the campus of Union College in Schenectady, New York. The ASEE was represented by Dr. B. R. Teare, Jr., Dean of Engineering, Carnegie Institute of Technology, and Mr. R. W. McFall, Manager, Technical Education, represented the General Electric Company. Twenty-six colleges from all parts of the country were represented at the seminar. The week was largely devoted to studying the educational techniques used in the General Electric Advanced Technical Programs, and evaluating their effectiveness for undergraduate academic teaching. One of the techniques presented was "learning by doing." In studying this technique, the visiting college instructors actually assumed the role of students.

The Future of Summer Schools

There has been a tendency in recent years to shorten the length of the summer school session and to hold a number of them at the place of the Annual Meeting of the Society for several days preceding or following the annual meeting. This reduces the expense to the registrants and makes it possible to attend both gatherings. Many would find it inconvenient or impossible to attend both meetings otherwise. Shorter sessions mean that the discussions in the school will be restricted to some specialty in the division. Sanitary Engineering only was discussed at the three-day Civil Engineering school at Dartmouth College this year.

Schools are sometimes desired at locations quite removed from the Annual Meeting. A school may be located at some central point for those expressing an interest in the subjects to be discussed. Such schools have operated for at least a week. The school in Engineering Mechanics was held at Iowa State College in September 1950; the Annual Meeting was held in June at Seattle, Washington.

Schools are initiated by some division, committee or section of the society that wishes to do so. Arrangements are made with some university or college to act as host and a preliminary program is set up. Application is then made to the secretary of the A.S.E.E. who presents it to the executive board for approval and allocation of funds necessary for the preliminary work in organizing and publicizing the school. Summer schools have been self-supporting ever since the first one financed by the Carnegie Corporation and there is no record where any funds advanced by the society have not been returned. Most

schools do not request funds underwritten by the Society.[1]

There is no conflict or relationship between these meetings and those of the technical engineering societies such as the American Institute of Electrical Engineers, or the American Society of Civil Engineers. The discussions are limited to the place of technical material in college courses and methods of presenting it to the students.

The growing complexity of modern engineering requires constant changes in curricula. More effective teaching or an increase in the length of the undergraduate courses seems necessary; perhaps both will be required. The American Society for Engineering Education has had a division of Educational Methods for some time; special committees on Teaching Aids and on Improvement in Teaching have been very active in recent years. The summer school provides a channel through which the work of these committees can be presented to individuals for intimate discussion, generally with profit to the experienced professors as well as the beginner. There are unlimited opportunities ahead for this very effective means of improving the preparation of engineering graduates for their life work, The Summer School for Engineering Teachers.

[1] Members interested in starting a summer school should write to A. B. Bronwell, Secretary A.S.E.E., Northwestern University, Evanston, Ill., for detailed information on procedures.

Sections and Branches

The **National Capital Area Section** held its Annual Meeting May 9, 1953 in the newly dedicated Engineering and Architecture Building, Howard University. The members were welcomed by Dr. Wm. Stuart Nelson, Dean of the University.

Carrying on the theme for the year, the topic for the morning session was "Effective Utilization of Engineers in Industry." Vice-Chairman Walther introduced the moderator of the panel: ASEE Vice-President M. M. Boring, General Electric Company; and the panel members: David L. Arm, Dean of Enginering, University of Delaware; Arthur F. Hartford, E. I. du Pont de Nemours Company; Harold Goldstein, U. S. Bureau of Labor Statistics.

The afternoon session was in charge of the Chairman of the Section's Committee on Young Engineering Teachers, Professor Ojalvo. He called on the Section Chairman, Dean Downing, to present the prize for the winning paper to its author, Assistant Professor John L. Artley, Johns Hopkins University. Following this, Professor Artley presented the highlights of his paper.

Chairman Downing conducted the annual business meeting during which the following officers were elected for 1953–54:

Chairman: Carl H. Walther, George Washington University

Vice-Chairman: J. C. Michalowicz, Catholic University of America

Sceretary-Treasurer: M. S. Ojalvo, University of Maryland

Council Representative: Henry H. Armsby, U. S. Office of Education (continuing for second year of his term).

Following the meeting there was Open House in the Engineering and Architecture Building for inspection of the new facilities.

ASEE-ECPD Conference Program

Wednesday, October 14, 1953

(Meetings on October 14 are Committee meetings open only to persons designated.)

Time	*Meeting*
8:00 A.M.	ASEE Executive Board Meeting (Breakfast)—Grill, Engineers' Club
10:30 A.M.	Meeting of ASEE Executive Board with Chairmen of ASEE Divisions and Members of General Council of ASEE representing Divisions—ASCE Board Room, 15th Floor, Engineering Societies Building.
12:00 Noon	ECRC Executive Committee Meeting (Luncheon)—Dining Room, Engineers' Club, 10th Floor.
2:00 P.M.	ASEE General Council Meeting—ASCE Board Room, 15th Floor, Enginering Societies Building.
6:30 P.M.	ASEE General Council Dinner and Meeting—Special Dining Room, 10th Floor, Engineers' Club.

Thursday, October 15, 1953

The following meetings and luncheon, sponsored by the ECRC and ECAC, are open to all ASEE and ECPD members and representatives.

9:30 A.M. Keystone Room, Statler Hotel, N. Y. C.
Theme: Creativeness in the Arts.
Eric A. Walker, *presiding,* Vice President of ASEE.
In Music. Virgil Thompson, Music Critic, *New York Herald Tribune.*
In Painting. John Ferren, Internationally known Painter.
A noted speaker will also be obtained to discuss creativeness in poetry.

12:30 Noon Luncheon—Georgian Room, Statler Hotel, N. Y. C.
L. E. Grinter, *presiding,* President of ASEE.
A Psychologist Looks at Creativeness, Its Environment and Its Measurement by Morris I. Stein, Professor of Psychology, University of Chicago.

2:00 P.M. Keystone Room, Statler Hotel, N. Y. C.
Theme: Creativeness in Engineering.
W. L. Everitt, *presiding,* Vice President of ASEE.
The Enginering Point of View. Maurice Nelles, Director, Borg-Warner Laboratory.
The Industrialist's Point of View. Fred Olson, Vice President for Research and Development, Olin Industries.

6:30 P.M. ECAC Executive Committee Meeting (Dinner)—Manhattan Room, Statler Hotel, N. Y. C.

Preliminary Program for ECPD Annual Meeting

Friday, October 16, 1953

The following meetings, luncheon and dinner are open to all ASEE members.

Time	*Meeting*
9:30 A.M.	Public meeting—discussion on accrediting. Hotel Statler, Georgian Room (under auspices of ECPD Education Committee).
12:00 Noon	Hotel Statler—Development of the St. Lawrence Seaway by General A. G. L. McNaughton, Chairman of Canadian Section of International Joint Commission.
2:00 P.M.	Symposium on Supply and Demand for Engineers—Hotel Statler, Georgian Room (in cooperation with the Engineering Manpower Commission, EJC).
7:00 P.M.	Annual Dinner—Hotel Statler. Report, Col. L. F. Grant, Chairman ECPD. Industry and Education by Horace Liversidge, Chairman of Board, Philadelphia Electric Company.

Reservation forms can be obtained from the Secretary ASEE, Northwestern University, Evanston, Illinois.

National Science Foundation to Support Travel of Scientists to International Meetings in 1954

The National Science Foundation will receive applications for a limited number of grants to assist in payment of travel expenses to six international scientific meetings in the mathematical, physical, and engineering sciences to be held during the latter half of 1954. The meetings of interest are:

International Union of Pure and Applied Physics, London, England, July 6–10, 1954. Applications should be received before December 1, 1953.

World Power Conference, Rio de Janeiro, Brazil, July 25-August 8, 1954. Applications should be received before December 1, 1953.

International Union of Theoretical and Applied Mechanics, Brussels, Belgium, July 28-August 2, 1954. Applications should be received before December 1, 1953.

International Mathematical Congress and International Mathematical Union, Amsterdam and The Hague, Netherlands, August 30-September 9, 1954. Applications should be received by January 1, 1954.

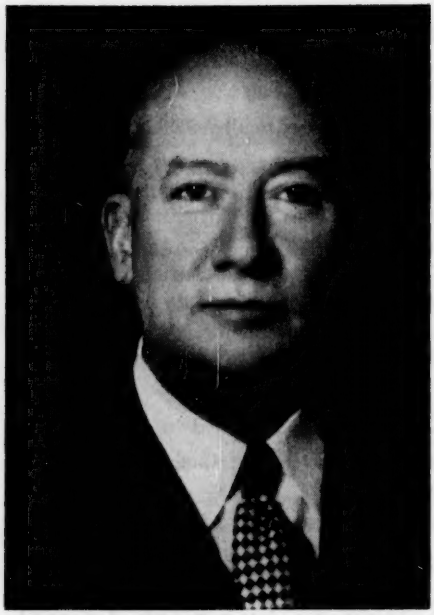
International Union of Geodesy and Geophysics, Rome, Italy, September, 1954. Applications should be received by January 1, 1954.

International Scientific Radio Union, Amsterdam, Netherlands, September, 1954. Applications should be received by January 1, 1954.

Applications are also being received for the following meeting to be held in 1953:

Pacific Science Congress, Quezon City, Philippines, November 16–28, 1953. Applications should be received before September 1, 1953.

Application forms may be obtained upon request from the National Science Foundation, Washington 25, D. C.



Citation to Dr. Rogers

To HARRY STANLEY ROGERS *for his achievements in bringing to engineering education a broad background of experience as an engineer, consultant, and administrator; for his inspirational leadership in the engineering profession and in engineering education; for his wise counsel and personal service to our Government during the war; for his devotion to civic enterprises and charitable organizations; for his leadership in professional society organizations, including his service as President of the Society for the Promotion of Engineering Education and Chairman of Engineers' Council for Professional Development; and for the high esteem in which he is held by his many colleagues, we present this 26th Lamme Award.*

Citation to Professor Obert

To EDWARD FREDRIC OBERT *for his inspired and vigorous teaching; for his sincere interest in his students as individuals; for his development of other good teachers; for his outstanding textbooks in the fields of thermodynamics and combustion engines; for his development of unique and effective methods of laboratory instruction; for his exceptional talent in guiding graduate students and directing research; and for his tireless search for better ways to present material in the classroom, we award this the 8th George Westinghouse Award.*

Lamme Award—1953—Harry Stanley Rogers

HARRY STANLEY ROGERS was born in Detroit, Michigan on August 7, 1890. His early education was obtained in the public schools of Detroit and of the suburb of Birmingham. His college training was pursued at the University of Wyoming from which he received the B.S. in civil engineering in 1914 and the Civil Engineering degree in 1926. He subsequently was awarded the honorary LL.D. by his alma mater in 1942, the Doctor of Science from Northeastern University in 1935, and the Doctor of Engineering from Rensselaer Polytechnic Institute in 1950.

Upon graduation from the University of Wyoming he served as instructor at the Universities of Iowa, Wyoming and Washington during which time he pursued graduate work at Iowa and Washington, and as assistant professor of Civil Engineering at Lafayette College. In 1919 he left education to become designing engineer with the Truscon Steel Company, but returned to the field of instruction in 1920 as professor of hydraulics and irrigation engineering at Oregon State College. In 1927 he was appointed Dean of Engineering and in 1928 the first Director of the Engineer-Experiment Station at Oregon State College. He served at Oregon State until the fall of 1933 when he accepted appointment as President of Polytechnic Institute of Brooklyn.

Throughout his college and teaching career he had an intermittent experience in irrigation, city and structural engineering including field and office practice and design. This experience prepared him for consulting in the field of water supply and sewerage which he did while in Oregon.

When appointed Dean at Oregon State he inaugurated and directed the development of a program of freshman engineering problems which was accompanied by a coordination of the work in engineering, physics and mathematics, and laid a foundation for the development of engineering ability as a way of thinking. As Director of the Engineering Experiment Station he initiated a sanitary survey of the Williamette Valley which laid the foundation for the regional correction of industrial wastes in the Williamette River Basin.

At Polytechnic Institute of Brooklyn he exercised leadership in the development of the program of undergraduate and graduate studies and of research and in a threefold expansion of the total student enrollment. Within this expansion the graduate school has been increased more than nine times. The current program in research has been developed from a very modest level to one involving three hundred people and the expenditure of more than two million dollars a year. He is currently Chairman of the Board of Polytechnic Research & Development Co., Inc., a company manufacturing microwave measuring equipment which is owned by Polytechnic Institute.

Throughout the years President Rogers has been active in the work of the American Society for Engineering Education, serving several terms on the Council, one term as Vice President, and two terms as President as well as on numerous committees. In 1932 he persuaded the Council to accept the invitation of Oregon State College to hold the 32nd annual convention on the Pacific Coast for the first time, and promoted the development of the Pacific Northwest and Pacific Southwest Sections which were brought into the Society at that convention. As President of the Society in 1945 he was chairman of the committee to write the new constitu-

tion under which the Society for the Promotion of Engineering Education and the Engineering College Research Association were united in the American Society for Engineering Education.

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York and a member of the Board of Visitors of the Air University, United States Air Force. He has been President of the Brooklyn Chamber of Commerce, the Rotary Club and the Downtown Brooklyn Association. He has been chairman of drives for charitable and civic purposes, including the United Hospital Fund, the Red Cross and the World War Fund. In 1946 he was presented the Gold Medal of the Downtown Brooklyn Association

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Sigma. His professional societies include the American Society of Civil Engineers, the American Institute of Consulting Engineers and the American Society of Mechanical Engineers.

George Westinghouse Award—1953—

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western University made possible the establishment of a large Technological Institute to replace the heretofore small engineering college. Because of the small size of the existing faculty, it was necessary for Professor Obert, though only an instructor at the time, to do much of the design of the Heat Power Laboratory. He was entirely responsible for the design and equipment of the Combustion Engine Laboratory and supervised the building construction and installation of equipment

Transfer." He has done research and published papers in the fields of thermodynamics, combustion engines, and machine design. He is an engineering consultant, and a registered professional engineer, with most of his work in the power field.

Professor Obert's extracurricular activities include being faculty advisor to the Society of Automotive Engineers since 1943; to the Triangle Fraternity since 1938; and, formerly, to the ASME stu-

tion under which the Society for the Promotion of Engineering Education and the Engineering College Research Association were united in the American Society for Engineering Education.

He likewise has been active in the Engineers' Council for Professional Development throughout its entire history, having been a member of the original Engineering Education Committee, a member of the Professional Training Committee, for nine years a member of the Council and for three years its Chairman. During his administration as Chairman, the work of the Selection and Guidance Committee was expanded to a nation-wide service and the pilot program of training in the first five years after college was inaugurated at the University of Cincinnati.

President Rogers has had wide interest in student affairs and activities. He served upon the athletic committees in three institutions and for a number of years was Chairman of the Board of Athletic Control and a member of the Pacific Coast Conference while at Oregon State College. He has been a national officer of his own fraternity and served a term as President of the National Interfraternity Council.

He has been widely and prominently identified with educational, civic and business interests. He has served as Vice Chairman of the Board of the Long Island College of Medicine, as a member of the Board of Higher Education of the City of New York, a member of the Board of the Associated Colleges of Upper New York and a member of the Board of Visitors of the Air University, United States Air Force. He has been President of the Brooklyn Chamber of Commerce, the Rotary Club and the Downtown Brooklyn Association. He has been chairman of drives for charitable and civic purposes, including the United Hospital Fund, the Red Cross and the World War Fund. In 1946 he was presented the Gold Medal of the Downtown Brooklyn Association for most distinguished service to Brooklyn. He is a Director of the Intertype Corporation, Namm-Loeser's Inc. and the New York Telephone Company, a Trustee of the Brooklyn Savings Bank and the Brooklyn Hospital, and Chairman of the Advisory Board of the Chemical Bank & Trust Company of Brooklyn.

In addition to his many other duties, Dr. Rogers found time to serve his government in the Office of Production Management as Chairman of the General Products Division of Priorities and as First Chief of the Rubber, Cork and Synthetic Rubber Branch. He left the services of the OPM in October 1941 but was called back to its successor the War Production Board in the spring of 1942 as Chief of the Rubber and Rubber Products Branch where he headed the control of natural rubber until October 1943. In 1943 he served as a member of the Truck Committee of the combined Raw Materials and Resources Board. He was a member of the National Engineers Committee which wrote reports for the State and War Departments on the industrial disarmament of Germany and Japan. For this last service he received the President's Certificate of Merit.

He is a member of Phi Kappa Phi, Tau Beta Pi, Sigma Tau, Sigma Xi, Pi Tau Sigma. His professional societies include the American Society of Civil Engineers, the American Institute of Consulting Engineers and the American Society of Mechanical Engineers.

George Westinghouse Award—1953—
Edward F. Obert

EDWARD FREDRIC OBERT was born in Detroit in 1910, and was educated in the Chicago Public Schools. His education at Northwestern University and the University of Michigan was interrupted several times because of the depression in the '30's. After two years in college, he was employed at the Western Electric Company in Chicago as an Engineer of Manufacture (1929, 1930). He returned to school and received the Bachelor of Science degree in 1933, and the degree of Mechanical Engineer in 1934, from Northwestern University. He then became an engineer in the office of the Inspector of Naval Materials (Chicago, 1934–1937), stationed at the Buda Company in Harvey, Illinois. His primary duties were the inspection and testing of diesel and gasoline engines, and all of the components in the laboratories of over 100 midwest suppliers of naval equipment. He received the degree of Master of Science from the University of Michigan in 1940.

Professor Obert joined Northwestern as an instructor in 1937, became an assistant professor in 1940, an associate professor in 1943, and a professor in 1950. While an instructor, the Walter P. Murphy gift of several millions of dollars to Northwestern University made possible the establishment of a large Technological Institute to replace the heretofore small engineering college. Because of the small size of the existing faculty, it was necessary for Professor Obert, though only an instructor at the time, to do much of the design of the Heat Power Laboratory. He was entirely responsible for the design and equipment of the Combustion Engine Laboratory and supervised the building construction and installation of equipment for all the heat power laboratories and designed many of the components. He has been director of all the Heat Power Laboratories since their inception and his plan of instruction is unique in several respects (the plan was described to the Society at the Annual Meeting in 1948). Professor Obert has had a tremendous influence on the lives of his students, many of whom decided on a teaching career. A professor at Penn State says, "His classroom, like his personality, was lively and stimulating. No stodgy droner from stale notes, every subject was made interesting and a challenge." A professor at M.I.T. writes, "During my eight years as a teacher in mechanical engineering, I have continually, consciously set for myself the task of attempting to maintain as sincere an interest in my students as Professor Obert had in us as students. My Association with him has had a great influence on my teaching."

Professor Obert's many interests are reflected in his writings. His books, which have been widely adopted and are well known to all teachers of mechanical engineering, include, "Internal Combustion Engines," "Thermodynamics," and "Elements of Thermodynamics and Heat Transfer." He has done research and published papers in the fields of thermodynamics, combustion engines, and machine design. He is an engineering consultant, and a registered professional engineer, with most of his work in the power field.

Professor Obert's extracurricular activities include being faculty advisor to the Society of Automotive Engineers since 1943; to the Triangle Fraternity since 1938; and, formerly, to the ASME stu-

dent branch (1937–1943). He is now serving on the ASEE committee for Ethical Standards, on the committee for Visual Aids, and is Illinois-Indiana representative to the Council. His society memberships are in ASME, SAE, Sigma Xi, Tau Beta Pi, Pi Tau Sigma, Triangle fraternity, and the Mark Twain Society. This year he was elected Chicago Section Chairman of the ASME.

College Notes

A grant of $150.00 to the **University of Pittsburgh** from the trustees of the **Westinghouse Educational Foundation** to continue for five years its present graduate professorship in the School of Engineering and to provide an additional five-year professorship in engineering has been announced.

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Dean William H. Hall of the **Duke University** College of Engineering has resigned, and Walter J. Seeley, Chairman of the Electrical Engineering Department, has been named Dean. A member of the faculty for 38 years, Hall has been dean of the college since it was established in 1939 and director of the University's engineering training program since 1937. He will retire late next year. Professor Seeley has been chairman of the Department of Electrical Engineering since 1935 and a member of the faculty since 1925.

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Bro. Jerome Parr, S.M., Associate Professor and Head of the Department of Mechanical Engineering, has been appointed Dean of the College of Engineering at the **University of Dayton** succeeding Bro. J. Albert Wehrle. Bro. William Bellmer, S.M., Head of the Department and Professor of Mathematics, has been appointed Associate Dean of Science.

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Howard University dedicated its new School of Engineering and Architecture Building as part of a two-day conference held on May 8–9, 1953, which included the dedication ceremonies, a conference on "Improving the Teaching of Engineering and Architecture," a dinner in honor of visiting delegates and representatives and the annual meeting of the National Capital Area Section, ASEE. Dean N. W. Dougherty, University of Tennessee, delivered the Dedicatory Address.

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One of the nation's top authorities on metals research has been appointed as Dean of Graduate Studies at **Carnegie Institute of Technology.** Dr. Robert F. Mehl, Head of the Metallurgical Engineering Department and Director of the Metals Research Laboratory at Carnegie, will immediately assume his new appointment as Dean of Graduate Studies in addition to his present positions.

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A gift of $1,200,000 from the Phillips Foundation of New York for a new electrical engineering center at **Cornell University** has been announced. The building will house Cornell's School of Electrical Engineering, the oldest such school among American colleges and universities. Construction is expected to begin this year.

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Dr. Webster A. Jones, Dean of the College of Engineering and Science at **Carnegie Institute of Technology**, has been appointed Vice-President in charge of industrial and government relations at Carnegie.

Report of the Secretary
1952-53

Each year in the Society's operation, the changing pattern of events brings forth new and interesting problems of vital importance to engineering education. The continuing projects, dealing with the familiar themes of Evaluation of Engineering Education, Teaching Aids, Improvement of Teaching, Cooperation Between Engineering Colleges and Secondary Schools, and Engineering Manpower, are all current centers of energetic Society activity. In addition to these, there arise new problems, such as those associated with the threat of unionization of the engineering profession, the proper infusion of concepts of ethics and professional precepts into our programs of engineering education, the necessity of recognizing and providing adequate incentives for good teaching to counteract the growing diversionary emphasis upon research, the preparation of a Manual of Graduate Study, the paper contest for young teachers, and the fuller integration of young teachers into Society activities.

It is difficult to draw general trends from such widely diversified activities but there seem to be several predominant areas of common interest. One of these is the attempt to appraise the directions of movement of the rapidly advancing frontiers of scientific and technological knowledge. There seems to be universal agreement that science and technology are undergoing evolutionary change at probably a more rapid rate than ever before and also that science is now exploring new areas which will be translated into significant engineering developments in the years ahead. But there is very little agreement as to what, if anything, should be done about the engineering curricula to meet this challenge.

A second element of broad general interest is the attempt to clarify the significance and thought processes involved in creative thinking as contrasted to analytical thinking. There seems to be general acceptance of the idea that the two thought processes are different and that instructional methods which develop analytical ability do not in general develop creative ability. There is also general acceptance of the fact that very little of our current engineering instruction is directed at developing creative ability, despite the fact that this is a primary function of engineering.

It is in problems such as these that the Society's function as a national forum, bringing together divergent views and subjecting them to critical analysis, can help to achieve clearer definitions and lead to logical, orderly solutions.

During the year, the Officers of the Society have devoted a great deal of time and personal service to organizing and developing the projects of the Society. President Woolrich has brought to the attention of the General Council and Executive Board numerous problems which have become major Society projects. Mr. Boring took an active lead in organizing the Young Engineering Teachers' Paper Contest and in assisting ASEE Sections in their problems. The contributions of Deans White, Lampe, and Walker are mentioned below in connection with the work of the Divisions, Committees, and Councils of the Society.

Unionization of the Engineering Profession

The vigorous efforts of labor unions to embrace the entire engineering profession presents a serious threat to the profession

which cannot be ignored. By preying upon elements of dissatisfaction and resentment in certain companies, the unions have succeeded in engulfing the entire engineering staffs.

President Woolrich has brought this growing situation to the attention of both the ASEE membership and the national engineering societies. His article "The Professional Engineer—Ascending to New Heights or Leveling Off to Mediocrity?" was published in the April issue of the JOURNAL, as well as in the *Journal of the National Society of Professional Engineers*, and reprints were distributed to the entire membership of the Engineering Manpower Commission. This article emphasized the dangers inherent in the "leveling off" influences of unionization and the fact that this can be a serious deterrent to engineering progress. He also stressed the obligation of companies to adopt a progressive policy of analyzing the causes of resentment and dissatisfaction among engineering employees and to take positive steps to remedy these situations.

This is a problem which affects every member of the profession and one which cannot be allowed to grow by default.

Instructional Manpower

President Woolrich has called attention to the fact that many engineering colleges are suffering from a shortage of competent faculty members. The inelastic budgets of colleges and the attractive offers which industry is making to faculty members are exacting a heavy toll of the engineering faculties. This situation will become increasingly serious over the next few years because of the sharp decline in graduates available to industry.

This is a major problem of both industry and the colleges, since it will influence the quality of engineering graduates in the future. President Woolrich has suggested that top-level conferences be arranged between the university administrations and companies to find a solution to this growing problem.

Graduate Students—Where Will They Come From?

The ever-rising ROTC quotas (from 40% to 60% of the enrolled engineering students) will present a serious problem over the next few years at the graduate level. Very few of the ROTC students will return to college for graduate study. The attractive job offers which industry is making to the balance of the graduates will further deplete the graduate ranks. It seems evident that graduate enrollments are destined to slump sharply over the next few years. What effect will this have upon the advancement of science and technology of the future?

Evaluation of Engineering Education

The ASEE Committee on Evaluation of Engineering Education has held four Committee meetings during the past year. This Commitee is undertaking a thoroughgoing investigation of engineering education and is endeavoring to interpret the rapidly changing movements of science and technology in terms of educational improvements. It will attempt to identify areas where significant improvement might be achieved and make recommendations for further studies in these fields. This Committee, under the Chairmanship of Dean L. E. Grinter, is working with numerous Sub-Committees in engineering colleges throughout the country. It is also working cooperatively with the ECPD Committee on Engineering Schools in those phases dealing with the minimum levels of education acceptable for accreditation purposes. This project is jointly sponsored by the Engineers Council for Professional Development, the Engineering Foundation, and the ASEE. A total of $6000 has been received from ECPD and the Engineering Foundation and a like amount has been pledged for next year.

European and Pan-American Conferences on Engineering Education

Considerable interest in engineering education has been expressed throughout

Europe and South America. A conference on engineering education known as ESEC was held during the week of January 12, 1953 in London. This was attended by representatives from the United States, Great Britain, Belgium, Denmark, France, Germany, Holland Italy Norway, Sweden and Switzerland. President Woolrich represented the ASEE at this conference. Dean Saville and Col. L. F. Grant represented the ECPD.

Another Conference on engineering education was the UPADI Conference of Pan-American Countries which this year held a meeting in Louisiana attended by Deans Lasalle and Steinberg.

ECAC Activities

Dean J. H. Lampe, Vice-President in Charge of ECAC, reports on many ECAC projects of importance to engineering education, among which are the following:

The ECAC Commitee on Engineering Manpower, under the Chairmanship of D. S. Bridgman, has drawn up an analysis of the current engineering manpower situation.

The ECAC Committee on Secondary Schools has been actively working with the AAAS, the National Science Teachers' Association, and several national mathematics societies in an effort to develop a nationwide program directed at improving the quality of instruction of mathematics and science in the secondary schools.

The Selection and Guidance Committee of ECAC under the Chairmanship of Dean N. W. Dougherty has worked with the Educational Testing Service during the past year in developing proficiency examinations at the senior college level for engineering students. These examinations will be completed and available from ETS in the near future for use by engineering colleges.

The Committee on International Relations of the ASEE has endeavored to expand its activities for International Guests.

A new Committee was appointed by ECAC during the past year to provide advice and assistance to the government's Mutual Security Agency and Technical Cooperation Administration in matters relating to technological education. This constructive relationship was requested by MSA–TCA as a result of a conference arranged by ECAC last fall. The Advisory Committee is under the Chairmanship of Dr. Ralph Morgan of the National Science Foundation.

ECRC Activities

The ECRC, under the Chairmanship of Vice-President Eric Walker, is completing a Directory of Current Research, which lists Research projects in progress in engineering colleges throughout the Country. This publication will prove of considerable value to college administrative officials, research personnel, government officials, and industrial people interested in research.

An active Committee of the ECRC, under the Chairmanship of Dr. Ray Woodrow, has rendered valuable service to Deans of Engineering Colleges and Directors of Research in keeping them informed of the current policies and practices of the government relating to research contracts.

Other Activities of ECRC are reported in the Vice-President's report.

Graduate Teaching Manual

The Graduate Division of the Society his just completed publication of a "Manual of Graduate Study in Engineering." This Manual is a thorough treatment of the objectives and organizational problems in graduate study, including faculty problems, admission and degree requirements, research requirements, language requirements, examinations, and other pertinent problems of graduate study. This manual was prepared by a distinguished group of faculty members all of whom have had extensive and varied experience in graduate teaching, research, and administration. The Committee was under the Chairmanship of Dr. Grinter.

Committee on Ethics

A number of professional engineers have expressed serious concern over the decline of ethical standards in engineering practice, particularly in the consulting and construction fields. There have been numerous requests that the colleges make a critical review of their methods of acquainting students with ethical precepts and the basic concepts of the engineering profession. A Committee under the Chairmanship of Dean C. J. Freund was appointed during the past year to study this problem. The Committee has made an extensive survey of opinion of engineers in industry, professional engineers, and teachers to get their views in this matter. A progress report will be presented at the Annual Meeting at Gainesville. It is expected that this project will continue for at last another year.

Teaching Aids Project

The project of reviewing and evaluating teaching aids in the fields of civil engineering, chemical enginering, mechanical engineering, mechanics and mathematics will be concluded by the summer of 1953. A bulletin listing the teaching aids which are considered by the reviewing committees to be of acceptable quality for engineering instruction will be published. The bulletins will be sold to the engineering colleges at cost price.

Improvement of Teaching

The Report of the Committee on Improvement of Teaching is in continued demand, as evidenced by the fact that over 10,000 copies have been requested by engineering colleges throughout the country. The response which this report has received is tangible evidence of its significant contribution to the improvement of engineering education.

Recognition and Incentives for Good Teaching

The growing emphasis upon research in engineering colleges is tending to shift the interest and efforts of faculty members away from engineering instruction toward research. This may cause a significant impairment of engineering instruction unless counteracting influences are brought to bear. In order to study this problem and recommend procedures for focussing attention upon high quality teaching, a Committee on Recognition and Incentives for Good Teaching was appointed during the past year.

Paper Contest for Young Engineering Teachers

The paper contest for Young Engineering Teachers, which was initiated during the past year, was received with considerable enthusiasm by the younger faculty members and has provided a wholesome stimulation of interest in Society participation on the part of these members. This experience has shown that the younger faculty members are eager to take part in Society functions, as well as to broaden their interests and develop their professional statures. It is estimated that over 75 papers were submitted.

Integration of Young Faculty Members into ASEE Activities

The Society has taken distinct steps to enlarge the participation of younger faculty members in ASEE activities. Many of the Sections of the Society have encouraged young faculty members to organize their own activities in conjunction with the Section meetings. This plan has proven exceedingly popular with the younger faculty members and has resulted in imaginative and well-planned programs. During the past year the Society has successfully expanded its membership among the younger faculty members by directing its membership campaign to faculty members in the lower academic ranks.

Participation of the younger faculty members in Society activities will enable them to broaden and enrich their outlook on engineering education and the engineering profession. It will bring to the Society more of that element of vigorous,

unorthodox thinking which is characteristic of young people and which is so vital to progress.

ECAC Conferences on ROTC Programs

The proposals of the Army and Air Force ROTC administrations to modify their programs in the general direction of eliminating the technical courses and introducing a more general type of ROTC program have been the cause of considerable concern on the part of administrative officers in engineering colleges. The principal objection to the new ROTC proposal is that the substitution of a general program for the technical courses may result in an educational program of a superficial character which would detract from both the interest and educational value of the program insofar as engineering students are concerned. Also, the substitution of general courses for a technical program might cause indiscriminate classification and assignment of engineering students after they graduate, so that technically trained ROTC graduates would be more likely to get service assignments outside of their professional field of specialization.

A series of conferences was arranged by Dean J. H. Lampe, Vice-President of ASEE in charge of ECAC, with officials of the Army and Air Force ROTC Administrations and also with the American Council on Education. This resulted in the clarification of the Air Force policy and a statement by the Army that for the present, the "Branch General" system would not be compulsory, but that technical units would be retained in schools which so desire.

Engineers' Joint Council

During the past year, the Society became a participating member in the Engineers Joint Council under action taken by the General Council of the ASEE in June 1952. Dean Thorndike Saville, the ASEE representative, was elected Vice-President of EJC. The Engineers' Joint Council currently has active committees in the fields of: Engineering Manpower, Increased Unity of the Profession, Constitution and By Laws, International Relations, Special Surveys, National Water Policy, Engineering Sciences, Labor Legislation, and Atomic Energy Legislation.

Teaching Position Advertisements in Journal

During the past year, a plan of advertising teaching positions in the JOURNAL OF ENGINEERING EDUCATION was inaugurated. This service has proven exceedingly helpful to the colleges in finding personnel.

Fall Meetings of ECAC and ECRC

The Fall Meetings of the ECAC and ECRC were held in conjunction with the Centennial of Engineering in Chicago. The conference program, attended by over 300 educators, featured papers on "The Modern Engineer Should Be Trained as a Scientist" and "What Are the Contemporary Demands on Engineering Curricula?" This was a joint meeting with the Engineers' Council for Professional Development.

The Executive Board has suggested that the Divisions and Committees of the Society consider utilizing these Fall meetings for the purpose of holding executive committee meetings to formulate their plans for the year's activities. This would provide a common meeting ground for the Council members and officers of Divisions and Committees throughout the Society. The ECRC–ECAC program would be open to the Society membership and would be developed along lines which would be of interest to all of those in attendance. This year, the Fall meetings will be held on October 15 at the Statler Hotel in New York.

Associate Institutional Membership

The Committee on Associate Institutional Membership, under the Chairmanship of Jesse McKeon, has carefully organized the program for soliciting Associate Institutional Memberships in the

Society. The Committee contains leading administrators in companies throughout the United States. They will direct invitational letters to responsible individuals in other companies. To date, this Committee has obtained 35 new Associate Institutional members. It is expected that the program will result in a substantial expansion of Associate Institutional Memberships in the Fall of 1953.

Summer Schools

Two summer schools have been authorized this year. The Industrial Engineering Division has planned a Summer School on the theme: "Quantitative Measures in Industrial Engineering Courses." The Educational Methods Division and the General Electric Company have pooled forces to conduct a Summer School which presents some of the material of the G. E. Company Advanced Engineering program to a select group of young teachers. A similar summer school, conducted last year, received high commendation from all those who attended.

Division Publications and Activities

Behind the scenes of ASEE activities, we often find people who are working quietly, effectively, and conscientiously—not for the glory, but rather to perform an important service. The various Division publications which are all self-financing and which bring to the Division membership new concepts of curricular material and teaching methods are examples of such service. Here are the editors who have done an excellent job this year: Professor M. B. Scott, Civil Engineering Bulletin; Professor T. T. Aakhus, Journal of Engineering Drawing; Professor Glenn Murphy, Bulletin of the Mechanics Division; Professor L. F. Kreisle, Machine Design and Manufacturing; Professor A. H. Cooper, Transactions of the Chemical Engineering Division; Professor Karl P. Hanson, Heat Power News and Views.

Atomic Energy Education

The Atomic Energy Committee, under the Chairmanship of Dr. H. H. Armsby, held one meeting at the Argonne National Laboratory, a considerable portion of which was devoted to a discussion, with the authors of the new "Sourcebook on Nuclear Engineering," of many matters of policy and of detail in connection with the preparation of this sourcebook. It is hoped that the book will be ready for use by the summer of 1954.

Committee on Society Function

This Committee is exploring ways to modify Society organization and improve the procedures in order to improve its functioning. An organizational Committee meeting was held in November and the work has been delegated initially to project teams.

Journal of Engineering Education

Two issues of the JOURNAL this year were devoted to papers presented at the Fall Meetings of the Society in conjunction with the Contennial of Engineering. These issues have received high commendation from many sources.

An article by President Eisenhower in the November issue scooped the press and presented views on technological manpower.

Division Activities

The following are some of the activities of the ASEE Divisions, under the direction of Vice-President W. C. White.

The Aeronautical Engineering Division held a mid-winter meeting in New York in January to prepare plans for joint meetings between its Division and the Institute of Aeronautical Sciences.

The Civil Engineering Division completed a report on Sanitary engineering. A joint Committee of ASEE and ASCE on Sanitary engineering was appointed. Considerable attention has been given to curricular development in Soil Mechanics, Construction, Transportation and Research. The Division publishes a Civil Engineering Bulletin three times a year.

The Mechanical Engineering Division continued publication of its bulletins

"Machine Design and Manufacturing" and "Heat Power News and Views."

The Mathematics Division has been actively working with the ECAC Committee on Secondary Schools and other societies in an effort to develop a nationwide approach to the improvement of mathematics instruction in the Secondary Schools.

Educational Methods Division has developed a continuing program on Improvement of Teaching in cooperation with sub-committees in engineering colleges and is evaluating the reports received by last year's Committee. The Division also has active sub-committees on Learning Aids, Inservice Training, Training of Teachers, Educational Research, Subject Matter, and Bibliography of Teaching.

The Engineering Drawing Division held its mid-year meeting at the University of Nebraska. This Division has taken an active role in helping ASA establish national and international standards.

Engineering Mechanics Division has published its Bulletin of Engineering Mechanics, and is emphasizing in its programs teaching techniques and scope of course content at both undergraduate and graduate levels.

Activities of the Relations with Industry Division this year were centered around its 5th annual College-Industry Conference in January, with papers on utilization of engineering talent, continued education of the engineer, education of talented students, and other interesting subjects.

Our active Technical Institutes Division has had committees working industriously on: Completion Credentials, Cooperation with Office of National Defense, Student Selection and Guidance, Curriculum Development, Teacher Training, Technical Institute Studies, Relations with Industry, Technical Institute Manpower Studies, and Relations with Professional Societies. A continuing feature of this Division is its Annual James McGraw Award for distinguished contributions to Technical Institute Education.

The Humanistic-Social Division has prepared a proceedings of its two Summer Schools. Also, jointly with the English Division, it has conducted a survey of liberal studies in the engineering curricula throughout the country.

The Engineering Economy Division has a Sub-Committee working on Aims and Objectives of Engineering Economy.

Much of the work of the Division of Young Engineering Teachers has been at the local level in promoting Section activities for young teachers and in encouraging entries in the Y.E.T. paper contest. Also six groups have been working in compiling information from the reports of the Committee on Improvement of Teaching in cooperation with the Educational Methods Division.

The Physics Division has collaborated with the Atomic Energy Committee in arranging programs dealing with atomic energy education.

The Manual of Graduate Study mentioned previously is a distinctive contribution of the Graduate Division.

Electrical Engineering is holding a series of conferences, attempting to clarify the fundamental concepts.

The Evening Engineering Education Division is currently struggling with problems of graduate school traditions and the restrictions which they impose.

The Cooperative Engineering Division held a Mid-Winter Workshop at Fenn College dealing with Cooperative Education Problems in Industry. The Division held meetings in Washington to clarify and correct discriminations in the PL. 550 Act.

The Architectural Engineering Division published two issues of the Architectural Bulletin for distribution to its members.

Chemical Engineering has emphasized instrumentation and also originality and other new tools in engineering education.

Formation of Japanese Society for Engineering Education

A consequence of the ASEE Mission on Engineering Education to Japan in the

summer of 1951 was the expression of a desire on the part of Japanese educators to organize a similar society. The Japanese Society for Engineering Education has been officially inaugurated and held its first Annual Meeting in July, 1953.

Annual Meeting

Several new innovations were introduced in the Annual Meeting this year. A business General Session was inaugurated on Monday afternoon for the purpose of acquainting the Society membership with some of the principal current Society projects and providing them with an opportunity to express their views on these projects.

The multiplicity of programs of the various Divisions and Committees of the Society is placing a severe strain on the schedule because of the number of conflicts. Perhaps a simpler system might be worked out in the future.

Society Operations

The Society has doubled its membership in the past six years. Its activities have grown rapidly in many diverse directions. This growth, although highly commendable, has placed a severe load upon the headquarters staff. Last year the Executive Board authorized appointments of a part-time Assistant Secretary and an additional half-time office secretary. This has provided partial relief, but it seems inevitable that if Society operations are to continue to grow, a further increase in staff will be needed.

There is no way in which a Society such as ASEE can avoid the inevitable inflation in costs, particularly when the Society operations are expanding. The cost of publishing the JOURNAL OF ENGINEERING EDUCATION alone has increased from about $8,000 before the war to the current figure of $26,000. This Soicety has a dues structure about one-third that of other national engineering societies and it operates with a very minimum overhead. Every operation which can possibly be streamlined has been the subject of careful scrutiny. The Society avoids extensive collateral services to its individual members and focuses its primary efforts upon the projects of greatest importance to the improvement of engineering education and to maintaining a close working liaison between its Councils, Divisions, Committees and Sections.

Respectfully submitted,
ARTHUR BRONWELL, *Secretary*

In the News

A program of international cooperation in education to assist in rehabilitation of the **University of the Philippines** has been undertaken by Stanford University. A $500,000 contract extending two and a half years has been signed by President Vidal A. Tan of the University of the Philippines and by Lloyd W. Dinkelspiel, president of the Stanford University Board of Trustees. The program is sponsored and financed by the U. S. Mutual Security Agency. Under terms of the contract, Stanford will send to Manila annually eight faculty specialists for a year each and three administrative consultants for shorter periods. They will be appointed from various other universities as well as Stanford. The University of the Philippines will provide 555,000 pesos ($277,500) for expenses of the educators and their families in Manila. Their task will be to assist the Colleges of Engineering, Education, and Business Administration of the Philippine national institution. This assistance will consist primarily of developing curriculums and teaching methods, including actual teaching in classes and faculty seminars.

Personnel of the Stanford project will also assist in selection of books, equipment, and supplies.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on Sunday evening, June 21, at the Primrose Grill, Gainesville, Florida. Those present were: W. R. Woolrich, *President;* M. M. Boring, J. H. Lampe, E. A. Walker, W. C. White, *Vice Presidents;* C. L. Skelley, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary,* and M. Merrill.

Secretary's Report

Secretary Bronwell reported as follows:

1. That preliminary plans for the joint meeting of ASEE and ECPD in New York, October 15–17 were formulated at a meeting of ECPD at which he was present.

2. There will be meetings of the ASEE Executive Board and General Council at the time of the Fall Meetings.

3. The Divisions and Committees of the Society will be encouraged to hold meetings at this time and rooms will be provided for such meetings.

4. The ASEE has received a total of $6,000 in contributions from the Engineering Foundation and the constituent societies of ECPD to finance the project "Evaluation of Engineering Education." Indications at present are that a similar amount will be forthcoming next year.

Treasurer's Report

The Annual Audit as of May 15 and projected estimated Audit as of June 30 were presented by the Treasurer. The net operations for the year indicated a deficit of $1,687.72 for the year.

Vice President White suggested that some of the Society money carried in cash might be invested. The Board recommended that the Committee on Financial Policy, under the Chairmanship of Dean F. M. Dawson, study this situation and make recommendations for the possible investment of $15,000 of Society funds.

The Board voted to accept the tentative Audit.

Suggested Budget for 1953–54

The Secretary presented a suggested budget for 1953–54. This provided for an increase in advertising income, which will result from a substantial increase in advertising rates, as well as an estimated increase in income due to new Associate Institutional members.

Other items of expense were comparable to those of the past year. The Secretary pointed out that the budget was extremely close. He stated that there is currently no provision for either insurance benefits or social security for the office secretarial staff. While both Assistant Secretary Watson and he have benefits as employees of Northwestern University, this matter is of consequence to the secretarial help. He recommended that a study be made with a view toward establishing some equitable plan for insurance benefits, and social security. He also stated that the office staff had been seriously overloaded during the past year, owing to a significant growth in Society activities, and that the proposed budget did not provide for any substantial increase in secretarial help in order to relieve this situation.

Treasurer Skelley stated that there were indications of further increases in printing costs and if this were to occur, the budget expense item would not be adequate to maintain the JOURNAL at its present volume. Professor Watson urged that the publication budget be increased, rather than reduced. He stated that it had been necessary to reject a number of papers which could have been published during the past year had the budget been sufficient. The June issue of the JOURNAL was cut drastically in order to minimize the budgetary deficit in printing costs.

The Board considered other means of increasing Society income. It was pointed out that the Associate Institutional Membership Drive would probably yield increased income in the future, but it was questionable that this would provide sufficient additional revenue to pay for rising costs of publication

and probable rising costs owing to the need for additional help in the ASEE Headquarters Office.

The Secretary pointed out that the Society could not expect any substantial increase in working funds as a result of expansion of individual membership, since the cost of servicing the membership practically equals the income from dues.

In view of the probable increase of cost of publications, the Board voted to recommend to the Council that the budgeted item of cost of publications be increased from $27,000 to $30,000 and that there be added to administrative salaries $600 to allow for part-time help during the current year.

The above appropriations would result in a budget deficit of approximately $3,600 during the current year. The executive Board requested that the Committee on Financial Policy study this matter and present recommendations to the General Council.

Report of Vice Presidents

Vice President White reported on activities of Divisions and Committees.

He also presented the two resolutions passed by the Committee on Evaluation of Engineering Education. The Board discussed these resolutions and referred them to the Council. It was recommended that no action be taken at this Annual Meeting, since this was a matter of considerable importance which should be widely discussed before action is taken.

Vice President Boring reported on the exceptional success of the YET Paper Contest. He stated that over 70 entries had been received by Sections throughout the country. He stated that many of the Sections have provided activities for the younger members in order to encourage their participation.

Vice President Lampe summarized activities of the ECAC, including:

1. The appointment of an Advisory Committee to consult with the Mutual Security Agency and Technical Cooperation Administration in matters relating to foreign aid programs of engineering education.

2. The activity of the Committee on Secondary Schools, which is working with other organizations in formulating a nation-wide program for better integration of Secondary School and college instruction.

3. The Selection and Guidance Committee has been working with the Educational Testing Service in developing a new series of tests at the graduate level.

4. The ECAC is giving consideration to problems of enginering colleges in attracting and holding younger faculty members.

Vice President Walker reported that the ECRC has completed publication of the Review of Current Research. This is a comprehensive tabulation of research projects in colleges throughout the country. It will be exceedingly helpful to industry and government in identifying colleges where there is competent faculty personnel in specific fields of research.

Evaluation of Engineering Education

This is reported in the meetings of the General Council.

The Executive Board approved a contract appropriation of $5,800 for the current year for a part-time secretary, the funds to be taken from contributions from ECPD and the Engineering Foundation. The Executive Board also voted to send resolutions expressing appreciation of the ASEE to the Engineering Foundation and to the constituent societies of ECPD for their financial support of the Evaluation of Engineering Education project.

Teacher Shortage

President Woolrich emphasized the serious shortage of engineering teachers, which is developing as a consequence of limited budgets in engineering colleges and attractive opportunities offered by industry to the younger faculty members. This matter was referred to the General Council for action.

Joint Sponsorship of Technical Conferences by ASEE and Other Major Engineering Societies

The Secretary presented a proposal for the establishment of a procedure in ASEE for encouraging the Divisions of ASEE to hold Conferences jointly with other major engineering societies. The objective is to identify those areas in which science and technology are moving rapidly ahead. Conferences would then be arranged in these specific areas, with leading authorities on the program to explore the subject thoroughly and identify fundamental concepts. The purpose would be to determine how the fundamental concepts can best be fitted into the engineering curriculum.

The Board suggested that the matter be given thorough consideration and recommended that it be presented to the General Council for discussion.

Branch of ASEE at the University of Illinois

A petition by the University of Illinois to establish a Branch of ASEE at Navy Pier was approved.

UNESCO Annual Meeting—University of Minnesota

The UNESCO Annual Meeting will be held on September 15–17 at the University of Minnesota. It was recommended that Mr. Wendell Burton and Professor R. C. Jordan be appointed as ASEE representatives.

Location of 1956 Annual Meeting

After consideration of outstanding invitations, the Executive Board decided to hold the 1956 Annual Meeting at the University of Toronto. The 1954 Annual Meeting will be at the University of Illinois and 1955 will be at the Pennsylvania State College.

* * * * * *

A meeting of the old and new members of the Executive Board of the American Society for Engineering Education was held on Wednesday, June 24, at 6:30 P.M. in the Oak Room, Florida Union, University of Florida, Gainesville, Florida. Those present were: W. R. Woolrich, *President;* L. E. Grinter, *President-elect;* M. M. Boring, W. C. White, J. H. Lampe, E. A. Walker, *Vice Presidents;* B. R. Teare, Jr., W. L. Everitt, *Vice Presidents-elect;* C. L. Skelley, *Treasurer;* G. W. Farnham, *Treasurer-elect;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Treasurer;* F. M. Dawson, and M. Merrill.

Financial Policy of the Society

Dean Dawson, Chairman of the ASEE Committee on Financial Policy, reported that the financial trends over the past 8 years were as follows:

A. The income from dues has increased from $18,600 to $49,000.
B. Advertising income increased from $3,800 to $13,400.
C. Total income has increased from $23,960 to $67,200.
D. The largest single increase in expense is the cost of the publications, which is increased from $9,600 to $26,500. The size of the JOURNAL has not changed over this period.
E. The expansion of Society membership and activities has necessitated adding an Assistant Secretary and also additional secretarial help in the headquarters office.

He discussed various possible dues structures and stated that a change in dues status would necessitate a letter ballot to the individual membership. Inasmuch as the Committee on Society Functions probably will not have any constitutional changes to propose for the next 6 months, he suggested that the matter relating to dues might be submitted to the Society membership independent of constitutional amendments.

A motion that the Executive Board recommend to the General Council a dues status of $6.00 for members under 35 years of age and $10 for members over this age was voted.

Applications for Associate and Affiliate Institutional Members

The following applications for Associate Institutional Membership were approved:

Columbia-Southern Chemical Corporation, Pittsburgh 22, Pennsylvania
Consumers Power Company, Jackson, Michigan
General Radio Company, Cambridge 39, Massachusetts
Lockheed Aircraft Corporation, Georgia Division, Marietta, Georgia
Louisiana Power & Light Company, New Orleans, Louisiana
Sprague Electric Company, North Adams, Massachusetts
Wisconsin Power & Light Company, Madison, Wisconsin
California Research Corporation
Lukens Steel Company
Socony Vacuum Oil Company
Florida Power Company
Boeing Airplane Company
Armour & Company
International Harvester
Deere Company
C.B.S.—Hytron Division
Toledo Edison Company

Request of Aeronautical Division

The Secretary stated that the Aeronautical Engineering Division had requested permis-

sion to hold a mid-winter meeting jointly with the Institute of Aeronautical Sciences. They would like to have ASEE underwrite a portion of the expense of the meeting. The discussion centered around the methods of financing mid-winter meetings of other Divisions and it was brought out that these are self-financing by charging a suitable registration fee. It was recommended that the Aeronautical Engineering Division be encouraged to proceed with this joint meeting, but that a suitable registration fee be charged so as to finance the cost of the meeting. The Division is of course at liberty to use its budget for this purpose, if it desires.

The question was raised as to whether or not the Agricultural Engineering Division should be retained as a Division in view of its declining activity. The Secretary stated that the Chairman of the Division had notified him that the Agricultural Engineers were holding a meeting during the month of either May or June and, because of this, the Division Officers had decided not to hold conferences at the Annual Meeting. The suggestion was made that Divisions which drop below a certain minimum level of activity should be either discontinued or revert back to Committee status so as to provide opportunity for other active groups that are qualified for Division status to come forward.

Committee to Recommend Personnel for ASEE Committees

Dr. Grinter stated that he would like to get as many nominations for Committee members for next year as possible. A number of suggestions have been received from the Chairmen of Sections and Divisions, as well as from Council members.

Bank Resolution

A resolution authorizing the President and Treasurer to co-sign checks jointly with either the Secretary or Assistant Secretary was authorized. This plan requires one signature at the Headquarters office and one signature by an officer outside of Headquarters.

Resolution to ASCE on Centennial Certificate

The Executive Board voted a resolution of thanks to the American Society of Civil Engineers for the Centennial of Engineering Certificate which was received by the Society.

Engineers Joint Council

The Secretary stated that he had been asked to serve on a Committee of the Engineers Joint Council to study the relationships between EJC and other national and regional societies, as well as individual members. He stated that during the coming year there will probably be a great deal of discussion as to whether or not EJC should incorporate some plan of individual membership and therefore requested recommendations from the Board.

The consensus of opinion of discussions which followed favored continuation of a council-type of organization, since the problems which EJC will handle are essentially those of advising the legislative and administrative branches of the Federal Government on broad problems relating to engineering. These can best be handled by a small group of competent authorities, rather than by establishing a complex and unwieldy system of individual membership, which would require referral of all matters to the individual membership. If a plan of individual membership is instituted, but the individual members are not consulted, they will justifiably feel left out. If they are consulted, the process becomes unwieldy so that it would be next to impossible to get answers in any reasonable period of time.

It was pointed out that EJC must find some way of establishing contact with individual members of the engineering profession who are interested in the EJC projects. Dean Grinter suggested the possibility of establishing conferences in large industrial centers at occasional intervals to discuss some of the major problems of EJC. The suggestion was also made that the EJC prepare News Releases suitable for publication in the various technical journals. The Executive Board favored the plan of setting aside a page in the Journal about every two or three months for news from ECPD and EJC.

Several amendments to the EJC Constitution were presented and acted upon.

Looking Ahead

Vice President White urged that the general theme and planning for the Annual Meeting be undertaken early in the Fall so that a properly coordinated program can be developed which would minimize conflicts.

Dr. Grinter asked for comments from the Executive Board as to the possibility of

centering the entire program next year around the theme "Evaluation of Engineering Education," since a great deal of vitalizing information seems to be stemming from this project. The discussion of the Board was favorable to this plan, although they felt that the matter should be placed up to the Division Chairmen to decide.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

In the News

A European Federation of Chemical Engineering was formally inaugurated at a Foundation Meeting held in the Maison de la Chimie in Paris on the 20th of June, 1953. The purpose of this Federation is to promote European co-operation in the fields of chemical engineering and equipment. The Federation owes its origin to efforts commenced in 1951, and which assumed a more concrete form during the course of the European Convention for Chemical Engineering and the ACHEMA X Chemical Engineering and Equipment Exhibition, which took place in 1952. These efforts have now been crowned with success.

Scientific and technical societies from Spain, Yugoslavia, Germany, Finland, The Netherlands Portugal, France, and Switzerland were represented at the inauguration. Many more scientific and technical societies, some of which are located in Norway, Denmark, Luxemburg and Austria, have signified their early intention of joining the Federation.

The activities of the Federation are managed by a committee, and the following gentlemen were elected members of this Committee of Management: Herbert Bretschneider, Germany; Hans C. Egloff, Switzerland; Francis A. Freeth, Great Britain and Jean Gérard, France.

The General Secretariats of the European Federation of Chemical Engineering are located in the Maison de la Chimie, 28 Rue Saint-Dominique, Paris, and in the Dechema-Haus, Frankfurt am Main, Rheingauallee, 25.

Minutes of General Council Meeting

A meeting of the General Council of the American Society for Engineering Education was held on Monday, June 22, 1953, at the University of Florida, Gainesville, Florida. Those present were: W. R. Woolrich, *President;* M. M. Boring, E. A. Walker, W. C. White, J. H. Lampe, *Vice Presidents;* C. L. Skelley, *Treasurer;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* H. P. Adams, William Allan, James M. Apple, H. H. Armsby, H. W. Barlow, H. R. Beatty, R. M. Boarts, C. A. Brown, S. W. Chapman, F. M. Dawson, W. W. Dornberger, W. L. Everitt, W. P. Godfrey, D. M. Griffith, C. O. Harris, S. C. Hollister, D. C. Hunt, H. Kuenzel, E. J. Lindahl, K. B. McEachron, Jr., F. H. Miller, Theodore H. Morgan, E. F. Obert, R. S. Paffenbarger, G. K. Palsgrove, N. F. Rode, L. A. Rose, Thorndike Saville, L. E. Stout, Ernst Weber, B. L. Wellman, K. F. Wendt, E. R. Wilcox, C. L. Wilson, S. E. Winston.

Secretary's Report

The Secretary presented a mimeographed report describing activities of the Society for the past year.

Treasurer's Report

The Treasurer discussed the Annual Audit. This is summarized in the minutes of the Executive Board meeting of June 20. The audit indicates a deficit of $1,687.72 for the year.

Budget for 1953–54

A tentative budget for 1953–54 was considered by the Council. Dean Dawson, Chairman of the Committee on Financial Policy, explained that the Soicety would probably operate at a deficit in the year ahead, the amount depending upon whether or not the Council wanted to maintain the JOURNAL OF ENGINEERING EDUCATION at its present level of operation. He stated that there is considerable expression of opinion among Society members that the JOURNAL should be expanded rather than contracted. He pointed out that a saving might be achieved by publishing the Yearbook every other year instead of every year. This would effect savings of about $3,000 in the alternate years, but would substantially load up the ASEE headquarters with extra editorial work in the years in which the Yearbook is published.

He explained that there is not much hope of reducing other items in the budget, since the substantial rise in prices, along with expansion of Society activities in recent years, has necessitated increased costs of operation. He also pointed out that the present dues classification system places an inordinate amount of labor on the Headquarters Office, since it is necessary to check the cards on every one of the 7,500 members each year to determine whether or not they have been promoted in rank and thus should pay higher dues. He stated that if a new dues structure is contemplated, it should be developed on an age basis with only two steps, so that members below a certain age limit, say 35, would pay one dues rate, and would increase automatically when the individual passes the transitional age.

Dean Dawson explained that the Society has a surplus of approximately three-quarters of the one year's operating expense and is in fairly good financial position, although it cannot sustain continuing deficits without weakening this position. He stated that a strong campaign is being put on by a Committee to get additional Associate Institutional Memberships and also that advertising rates have been increased in order to bring in additional revenue.

The Secetary explained that the office staff consists of himself and an Assistant Secretary, both part-time, and three office secretaries. This amounts to approximately one staff member for every 1,500 members. The other major engineering societies operate with Headquarter staffs of the order of 100 people and usually have approximately one staff member to every 300 members. He explained that the staff loading was extremely heavy and is growing rapidly as the Society activities expand. He stated that the Society should have four or five office

secretaries with the present level of operations.

Two recommendations of the Executive Board were considered by the General Council. These are:

1. Approve the tentative budget as proposed, and, in order to meet the publication budget, discontinue publication of the Yearbook during the current year. It was recognized that this would alleviate the budget problem for the current year, but the problem would have to be faced all over again next year when the Yearbook is published.

2. Increase the publication budget to $30,000 and publish the Yearbook this year. Also add $600 to salaries in order to provide part-time help which is seriously needed in the Headquarters Office. This would result in a budget deficit of approximately $3,600 for the coming year.

Professor H. Russell Beatty moved that the second proposal be accepted and recommended that a proposal be submitted by the Committee on Society Finance to the membership for an increase in dues.

A vote was taken to determine how many of the Council members would prefer publishing the Yearbook every two years, rather than every year. The majority of Council members favored publishing the Yearbook every year. The matter was deferred until the Friday morning meeting.

Reports of Vice Presidents

Mimeographed reports of the Vice Presidents were distributed to Council members.

Unionism in the Engineering Profession

President Woolrich reviewed the situation with respect to the growth of unionism in the engineering profession. He mentioned the testimony given by ESA before Committees of Congress on the amendments to the Taft-Hartley Law in favor of strong union legislative provisions, and stated that both EJC and NSPE presented arguments for legislative provisions which would protect the engineer from involuntary unionism. He also mentioned that the ASEE has taken an active role in this matter and has worked with and through the Manpower Commission of the Engineers' Joint Council in developing an awareness of the threat throughout the engineering profession.

One of the objectives of ESA is to set up student chapters in engineering colleges. Discussion of the Council members revealed no knowledge of any such student branches.

President Woolrich emphasized the fact that the salary scales of engineers often do not provide incentive for the experienced engineer and that this is a source of irritation which tended to encourage unionization. This matter has been called to the attention of industry by means of an editorial prepared by President Woolrich and distributed by the Engineering Manpower Commission.

It was recommended that President Woolrich's report be sent to the deans of engineering colleges with the recommendations that they discuss this problem with engineering students. It was also recommended that the article be sent to the Committee on Guidance of the Engineers' Council for Professional Development.

Shortage of Engineering Teachers

President Woolrich commented on the serious problem which many engineering colleges are facing in the shortage of competent teachers. He stated that many experienced teachers are being lured into industry at salaries beyond the reach of engineering colleges. He recommended that a Committee of three to five people be appointed, representing top men in industry and presidents of colleges or universities, to work out a solution of this problem. He stated that unless a rather positive solution is arrived at within a short time, there will be a shortage of over 1,000 engineering teachers by this Fall.

Upon motion by Professor Beatty, the Council voted to authorize appointment of the Committee consisting of top level industrial representatives and college presidents to discuss this problem and attempt to work out a solution.

Comments on the Report of the Committee on Evaluation of Engineering Education

Two resolutions,* approved by the Committee on Evaluation of Engineering Education for referral to the General Council were discussed. The Council recommended that the ASEE proceed cautiously on the second resolution. They suggested publication of the reports and a thorough discussion by the Society membership at one of the General Sessions before the matter be implemented.

* To be published in Oct. issue of JOURNAL.

Dean Everitt recommended that the report be transmitted to the Committee on Accreditation of ECPD for study and referral to constituent societies for their comments.

The first resolution was moved by Dean Hollister and seconded by Dean Saville and approved by the General Council.

The Secretary mentioned that the Engineering Foundation and the constituent societies of ECPD had contributed $6,000 for financing the project Evaluation of Engineering Education during the past year and an additional $6,000 has been pledged for the coming year. He also mentioned that Dr. Pletta will be retained as part-time Secretary of the Committee on Evaluation of Engineering Education during the coming year. He proposed resolutions of appreciation to the Engineering Foundation and the constituent societies of ECPD, which were favorably voted by the Council.

Plans for the Fall Meeting for ASEE–ECPD

The Secretary stated that the Fall meetings of the ECRC and ECAC this year will be held in conjunction with the Annual Meeting of the ECPD at the Statler Hotel in New York on October 15–17. The ECAC–ECRC will have a conference program, with a luncheon speaker, dealing with the general theme of creative thinking in the arts and creative thinking in research. The entire conference program is open to the ASEE membership.

The Secretary also mentioned that provisions would be made for meeting rooms for Divisions and Committees which wish to hold Committee meetings in order to get their activities for the year started early in the Fall. The General Council will probably meet on October 14 at the Statler Hotel in New York.

Continuation of Paper Contest for Young Engineering Teachers

President Woolrich asked for comments on the Young Engineering Teachers' Paper Contest, which was inaugurated for the first time this year. The Council members expressed considerable interest in this program as a means of developing active participation of younger faculty members and awareness on the part of these faculty members of the problems confronting engineering education. They urged that the competition be continued.

Committee on Annual Meeting

The Secretary suggested that a Committee be appointed to review the Annual Meeting and make recommendations for improvement. He stated that the number of conferences of the various Divisions and Committees have grown to the point where serious conflicts are involved. On some afternoons there were twelve to fourteen conferences scheduled concurrently, and in some of these there are overlapping areas of subject matter, despite concerted efforts to minimize these conflicts. The present plan of holding three General Sessions in the mornings reduces the time available for the Division conferences. This year an innovation was attempted in the form of a General Session on Monday afternoon to inform the Society membership of current developments in major Society projects and provide an opportunity for membership discussion relating to these projects. This innovation proved exceedingly successful. He stated that in the past the Executive Board has handled the planning of the Annual Meeting at regular Executive Board meetings, but the pressure of other matters of business did not make it possible to devote sufficient time to explore the matter thoroughly. A committee appointed specifically for this purpose could meet once or twice during the year and explore in careful detail the problems relating to the Annual Meeting and then prepare recommendations for consideration by the Executive Board.

Exhibits at the Annual Meeting

Numerous requests have been received from commercial organizations for permission to hold exhibits at the Annual Meeting. The Secretary stated that the Engineering Drawing Division usually holds exhibits at the Annual Meeting, but for the most part other exhibits are discouraged because of the additional burden it places upon the Host Institution. However, it was thought advisable for the General Council to consider this matter and decide whether or not they wanted to have exhibits at future Annual Meetings.

Dean Wendt moved that commercial exhibits be barred from Annual Meetings. The motion was passed. It was the sense of the Council that this did not bar exhibits which are specifically requested by a Division of the Society, but that it should be used to discourage commercial exhibits in general.

Honorary Memberships

The General Council unanimously passed a resolution to grant honorary memberships to Dean H. P. Hammond and Dean A. A. Potter.

Location of 1954 and 1955 Annual Meetings

The Secretary mentioned that the 1954 Annual Meeting will be held at the University of Illinois, June 13–18. The 1955 meeting will be at Pennsylvania State College and the 1956 meeting will be at the University of Toronto.

Life Membership

The Secretary presented a list of applicants for life membership all of whom had satisfied the constitutional requirements. Dean Dawson moved acceptance and the Council unanimously passed the motion.

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A meeting of the General Council of the American Society for Engineering Education was held Friday, June 26, 1953, at 7:30 A.M. in the Training Room, University of Florida, Gainesville, Florida. Those present were W. R. Woolrich, *President;* W. C. White, *Vice President;* A. B. Bronwell, *Secretary;* C. E. Watson, *Assistant Secretary;* newly-elected officers: L. E. Grinter, *President-elect;* W. L. Everitt, B. R. Teare, Jr., *Vice Presidents-elect;* G. W. Farnham, *Treasurer-elect;* William Allan, J. M. Apple, H. H. Armsby, H. W. Barlow, H. R. Beatty, R. M. Boarts, G. P. Brewington C. A. Brown, Stuart W. Chapman, N. A. Christensen, F. M. Dawson, W. W. Dornberger, M. A. Durland, F. W. Edwards, W. P. Godfrey, C. O. Harris, S. C. Hollister, D. C. Hunt, H. Kuenzel, Eric J. Lindahl, J. C. McKeon, F. H. Miller, C. W. Muhlenbruch, R. S. Paffenbarger, G. K. Palsgrove, F. H. Pumphrey, N. F. Rode, H. P. Rhodes, Thorndike Saville, E. B. Stavely, L. E. Stout, R. W. Van Houten, R. E. Vivian, Ernst Weber, B. L. Wellman, Kurt Wendt, H. H. Wheaton, G. R. Wilcox, S. E. Winston and M. Merrill.

Engineers Joint Council

Dean Saville commented on activities of EJC, stating that it was proceeding slowly and cautiously, but making significant progress on a number of major problems, including a study of the problem of unionization of the profession, amendments to the Taft-Hartley Law, amendments to the Atomic Energy Act, and recommendation of policies to the National Water Policy Board. He stated that at present EJC is not trying to create a new engineering society in competition with existing professional societies, but rather is trying to work by delegated authority with the existing societies.

Recommendations from the Committee on Financial Policy

Dean Dawson, Chairman of the Committee on Financial Policy, presented the report of the Committee which is published elsewhere in this issue.

The Council discussed the possibility of effecting a saving in costs of printing the JOURNAL OF ENGINEERING EDUCATION by using the offset printing process. It was moved that the President authorize a Committee to investigate ways of effecting possible savings in printing costs, but consistent with the maintenance of attractiveness and effectiveness. The motion was approved.

Dean Saville stated that the ASEE has now become of age and must make its influence felt in its relationships with ECPD, EJC, and other engineering societies. He stated that this can be done only if the Society has representatives at these meetings and urged that adequate provision be made for travel budget for officers and the Secretary.

A motion was made to adopt the recommendations of the Committee on Financial Policy. This was unanimously passed by the Council.

Recommendations of the Committee on Evaluation of Engineering Education

The Council considered the proposals of the Committee on Evaluation of Engineering Education, specifically the procedure for accreditation of the Professional General and Professional Scientific stems, as well as the desirability of using a starred designation on curricula of exceptional merit.

In the discussion it was pointed out that there is need for raising the standards of accreditation of engineering curricula and also of providing for recognition of exceptionally meritorious programs. However, there was considerable discussion as to the difficulties which might be encountered by using a starred designation for meritorious performance, it being indicated that this procedure would involve many difficult procedural ramifications and would be subject

to widespread criticism emanating from schools which feel that they deserve such recognition, but have not received it. It was pointed out that other organizations which have attempted meritorious designation of this general character have abandoned it.

The previous Council Meeting had recommended publication of the Report of the Committee on Evaluation of Engineering Education in an early issue of the Journal, so no further action was taken.

Sponsorship of Joint Conferences

A resolution authorizing the sponsorship of technical conferences jointly with other engineering societies, upon approval by the ASEE Executive Board, was approved.

The Secretary presented a proposal for the establishment of a procedure for developing technical conferences in specialized areas under joint sponsorship of the Divisions of the ASEE and other engineering societies. The purpose is to identify those areas where the science and technology are moving ahead rapidly. Conferences would then be arranged in these specific areas with the objective of exploring the subject thoroughly, identifying the fundamentals involved, and determining how these might be worked into the engineering curriculum.

It was moved by Dean Hollister that the Society give active and vigorous support to such a program and that the President appoint a Committee to study areas which may be suitable for development of such programs and take steps to implement the proposal. The motion was approved.

Proposal for Project on Prediction of Success

Professor Wilcox presented a request prepared jointly by the Division of Relations with Industry and the ECAC Committee on Selection and Guidance. The request was for ASEE support for a testing program, to be conducted by the Educational Testing Service, which would determine if there is any basis for reliable prediction of success of engineering graduates.

It was moved that the General Council endorse this activity. Motion passed.

Resolutions of Technical Institute Divisions

The Secretary read three resolutions proposed by the Technical Institute Division.

The first resolution proposed that Technical Institutes be recognized as "institutions of higher learning." Dr. Rhodes stated that the Veterans Administration requires that institutions which are eligible to receive veterans benefits must be categorized either as secondary schools or as institutions of higher learning. He stated that Technical Institutes are definitely not secondary schools and that the Veterans Administration had been hesitant without proper authority to classify them as "Institutions of Higher Learning." He stated that if a Technical Institute could show that 40% of its curriculum is transferable for college credit, it would be classed as "Institution of Higher Learning" and would receive veterans benefits.

Dean Grinter pointed out that whether or not a particular institution is an "Institution of Higher Learning" is not a matter which can be settled by a legislative procedure. Professor Christensen stated that he did not see how the ASEE could deny Technical Institutes the privilege of being recognized as institutions of higher learning, assuming that they have accredited programs. Dr. Armsby moved that the resolution be adopted and the Council voted 14–5 in favor of the resolution.

The second resolution proposing that the Technical Institute Division have a representative on the EJC Manpower Commission was a matter of administrative action and Dean Grinter indicated that he favored the proposal.

The third resolution asking ASEE endorsement for the use of "engineering technician" to designate technical institute graduates and also "associate degree" as a degree title was considered by the General Council in June, 1952.

This was considered by a Committee which recommended that the ASEE accept the resolution as stated, with reservations regarding the use of the word "engineering" as a qualifying adjective. Discussion of the Council indicated that the Council members did not feel that the report was specific enough to provide a basis of action.

Dean Hollister stated that the entire matter of engineering degrees is a subject which should be considered in its entirety by the Society and recommended that an ad hoc Committee be appointed to study this problem. He moved that the President be authorized to appoint an ad hoc Committee to study the designation of degrees. Motion was passed.

Dr. Rhodes stated that the Technical In-

stitutes are not granting and do not wish to grant professional degrees. He pointed out that many Junior Colleges are now granting Associate Degrees, which is what is proposed in the resolution, and that this degree has been recognized by the U. S. Government.

Professor Beatty emphasized that the engineer and the technician are a team in industry and that the technicians need to have their positions recognized by members of the engineering profession. This is something that Technical Institutes cannot do alone, but with the aid of the engineering profession, they can get the necessary recognition.

Committee Reports

Dean Freund reported on the work of the Committee on Ethics, stating that the study will be continued during the coming year and that the problem should be kept constantly before engineering educators. He suggested that the Committee might perform a useful service by preparing subject matter references which would assist teachers in obtaining case material.

Professor Muhlenbruch reported that the Committee on Teaching Aids expected to complete its work on publication of the catalogue on visual aids by June, but delays have forced completion of the project to be moved ahead until this Fall. He suggested that the work of the Committee be turned over to a standing committee of the Educational Methods Division after the Teaching Aids Committee has completed its assignment.

Mr. Jess McKeon, Chairman of the Committee on Associate Institutional Memberships, reported that the Committee had increased the number of Associate Institutional Memberships from 3 to 37 in the first year's operations and that 16 additional companies had been approved at the Executive Board Meeting, June 24.

Public Relations Committee

Professor Lisle Rose, Chairman of the Committee on Public Relations, briefly commented on the work of the Public Relations Committee during the year and also its work in publicizing the Annual Meeting.

Resolution of Committee on Secondary Schools (ECAC)

Profesor Lisle Rose presented a resolution, urging industrial and government support for improvement of teaching, which had been favorably voted by the ECAC and referred to the Council, was moved and voted by the General Council. It was recommended that this resolution be sent to the Edison Foundation and to the Future Scientists of America. The Committee on Secondary Schools will implement the recommendations in this resolution.

Committee on Improvement of Society Functions

Secretary Bronwell, reporting for Dean Teare, commented on the progress of the Committee on Society Function. This Committee has held three meetings and three sub-committees have been appointed to prepare recommendations in various areas of Society activities. The principal objective is to study the Society structure and functions, with a view toward achieving a clearly defined structural organization for optimum performance, securing better coordination of Society activities, providing channels for the upward flow of ideas, and providing promotional channels for optimum utilization of the Society's competent manpower.

Expression of Appreciation from President Woolrich

President Woolrich expressed his deep appreciation to the Officers of the Society for the excellent cooperation which he had received during the past year and also to the Officers of Divisions, Sections, Branches, and members of the General Council for the wholehearted and progressive spirit in which they had carried forward the responsibilities of the Society during the year.

Comments by Dean Grinter

Dean Grinter stated that he hoped that the Divisions, Sections and Committees of the Society would give serious consideration to development of the project "Evaluation of Engineering Education" during the coming year, with a view toward pointing up this project at the next Annual Meeting. He paid tribute to the retiring members of the Board and expressed his grateful appreciation for the very able group of officers whom the Society had selected for the coming year.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh		W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	University of Pennsylvania	Dec. 5, 1953	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Johns Hopkins University	Oct. 3, 1953	C. H. Walther, George Washington University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeastern	North Carolina State College	March 18–20, 1954	J. R. Cudworth, University of Alabama
Southwestern	University of New Mexico	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ADAMS, WILLIAM F., Associate Professor of Electrical Engineering, Texas A. & M. College, College Station, Tex. N. F. Rode, M. C. Hughes.

ANDREW, EDWARD H., JR., Assistant Professor of Electrical Engineering, Texas A. & M. College, College Station, Tex. N. F. Rode, R. M. Wingren.

ANDREWS, ROBERT V., Associate Professor of Chemical Engineering, Texas A. & M. College, College Station, Tex. J. D. Lindsay, F. F. Bishop.

BENISCHEK, HOWARD W., Associate Professor and Chairman, Petroleum Engineering, University of Oklahoma, Norman, Okla. F. C. Larson, J. F. Brookes.

BENNETT, ROBERT B., Professor of Chemical Engineering, University of Florida, Gainesville, Fla. W. H. Beisler, J. M. Duncan.

BOYLAN, DAVID R., Assistant Professor of Chemical Engineering, Iowa State College, Ames, Iowa. M. Smutz, B. F. Ruth.

BUTCHER, HAROLD G., Instructor, Technical Institute, Franklin University, Columbus, Ohio. L. D. Jones, W. D. Turnbull.

CALDWELL, JAMES W., Associate Professor of Industrial Engineering, Pennsylvania State College, State College, Pa. G. L. Thuering, B. W. Niebel.

CHANG, SHELDON SHOU-LIEN, Assistant Professor of Electrical Engineering, New York University, New York, N. Y. B. J. Ley, D. B. Porter.

CLEAVER, FREDERICK W., Instructor in Industrial and Engineering Administration, Cornell University, Ithaca, N. Y. M. W. Sampson, R. F. Chipak.

COOPER, LOUIS M., Instructor in Mechanical Engineering, Milwaukee School of Engineering, Milwaukee 15, Wis. F. J. Van Zeeland, F. Kaufmann.

CRANCH, EDMUND T., Assistant Professor of Engineering Mechanics, Cornell University, Ithaca, N. Y. H. C. Perkins, D. F. Gunder.

CYPHERS, HOWARD E., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. G. K. Palsgrove, J. G. Fairfield.

DAY, EMMETT E., Associate Professor of Mechanical Engineering, University of Washington, Seattle, Wash. L. B. Cooper, M. Guidon III.

DEMOREST, WARREN L., Instructor, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

DILLON, FRANK H., Professor of Engineering, Bradford Durfee Technical Institute, Fall River, Mass. A. A. Stewart, E. R. Williams.

DUDLEY, DAVID A., Assistant Director, Admissions, Assistant Professor of English, Massachusetts Institute of Technology, Cambridge, Mass. H. R. Bartlett, L. Bryant.

FLOE, CARL F., Professor of Metallurgy, Massachusetts Institute of Technology, Cambridge, Mass. W. R. Woolrich, A. B. Bronwell.

FRASCH, JOSEPH F., Director, Franklin University, Columbus, Ohio. L. D. Jones, W. D. Turnbull.

FREGETTO, DOUGLAS F., Instructor in English, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

GIEDT, WARREN H., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif. P. B. Stewart, E. D. Howe.

HARMER, RICHARD L., Dean, Technical School, Franklin University, Columbus, Ohio. L. D. Jones, W. D. Turnbull.

HAZEL, JAMES F., Associate Professor of Chemistry, University of Pennsylvania, Philadelphia, Pa. A. Jorgensen, E. F. Stover.

HNATIUK, BOHDAN T., Assistant Professor of Aeronautical Engineering, University of Notre Dame, Notre Dame, Ind. R. S. Elsenberry, F. N. Brown.

HOUP, KENNETH W., Associate Professor of English, Pennsylvania State College, State College, Pa. R. E. McCocal, V. E. Neilly.

HUGHES, VIRGIL L., Head, Engineering, Southern State College, Magnolia, Ark. G. F. Branigan, N. H. Barnette.

JONES, EARL E. R., Principal Extension Representative, University of California, Berkeley, Calif. E. D. Howe, A. S. Levens.

JONES, GEORGE L., JR., Assistant Professor of Chemistry, Clarkson College of Technology, Potsdam, N. Y. C. Hecker, D. G. Stillman.

KELLER, EARL W., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. T. F. Jones, Jr., E. A. Williams.

KLINE, BENNET E., Associate Professor of Industrial Management, Purdue University, Lafayette, Ind. M. Graney, C. W. Beese.

KONECNY, ANTHONY R., Instructor in Mechanical Engineering, University of Washington, Seattle, Wash. E. Laitala, B. T. McMinn.

KRAMM, HARTZELL M., Instructor in Drawing, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

LABES, WILLIS G., Assistant Professor, Fire Protection and Safety Engineering, Illinois Institute of Technology, Chicago, Ill. R. H. Owens, J. J. Ahern.

LAMONT, NORMAN, Assistant Professor of Petroleum Engineering, Texas Technological College, Lubbock, Tex. W. L. Ducker, D. E. Holcomb.

LARSEN, MERWIN J., Head, Electrical Engineering, University of Florida, Gainesville, Fla. P. H. Nelson, L. E. Schoonmaker.

LAZAR, NICHOLAS M., Associate Professor of Engineering, Wayne University, Detroit, Mich. R. H. Schoonover, R. W. Grant.

LOANE, GEORGE H., Assistant Professor of Electrical Engineering, University of New Brunswick, Fredericton, N. B., Canada. E. O. Turner, A. B. Bronwell.

MACLEAN, GEORGE R., Associate Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. Y. C. Yang, E. McHugh.

MATLOCK, HUDSON, Assistant Professor of Civil Engineering, University of Texas, Austin, Tex. P. M. Ferguson, C. W. Morgan.

MCDONALD, PATRICK H., JR., Research Associate Professor, Engineering Research Dept., North Carolina State College, Raleigh, N. C. V. W. Conner, G. W. Smith.

MCHUGH, CARL M., Associate Professor of Drawing and Design, Clemson Agricultural College, Clemson, S. C. D. W. Bradbury, J. E. Shigley.

MITCHEL, ROY D., Instructor in Engineering Drawing, Odessa College, Odessa, Tex. R. T. Northrup, A. B. Bronwell.

MOORE, LEO B., Assistant Professor of Industrial Management, Massachusetts Institute of Technology, Cambridge, Mass. A. B. Bronwell, W. R. Woolrich.

MOSKUITINOFF, IVAN T., Lecturer in Civil Engineering, City College of New York, New York, N. Y. W. Allan, W. L. Willig.

NEWTON, JOHN P., Associate Professor of Electrical Engineering, Rutgers University, New Brunswick, N. J. S. Fich, P. S. Creager.

O'CONNER, JOHN J., Assistant Dean, State University Maritime College, Fort Schuyler, New York, N. Y. J. J. Foody, C. H. Young.

PEACH, MILTON O., Associate Professor of Engineering Mechanics, University of Notre Dame, Notre Dame, Ind. J. A. McCarthy, W. L. Shilts.

POETZ, ROBERT G., Instructor in Chemistry, Newark College of Engineering, Newark, N. J. D. W. Dickey, M. W. Braunn.

QUINLAN, MAURICE D., Coordinator, College Relations, Personnel, Western Electric Co., New York, N. Y. O. Carpenter, D. S. Bridgman.

RAM, GERSON L., Instructor in Chemistry, Newark College of Engineering, Newark, N. J. D. W. Dickey, M. W. Braunn.

REED, MARION B., Assistant Professor of Electrical Engineering, Louisiana State University, Baton Rouge, La. M. R. Voorhies, L. V. McLean.

RETHERFORD, ROBERT C., Associate Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. T. J. Higgins, H. A. Peterson.

RUTLAND, JASPER L., Instructor in Civil Engineering, The Citadel, Charleston, C. C. J. C. Key, L. S. LeTellier.

ST. JOHN, JOHN D., Instructor in Electrical Engineering, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

SCHMERZLER, LAWRENCE J., Lecturer in Mechanical Engineering, Newark College of Engineering, Newark, N. J. G. B. Thom, W. Ornstein.

SCHWICHTENBERG, RICHARD J., Instructor in English, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

SWOFFORD, RALPH P., JR., Brig. Gen., Commandant, USAF Institute of Technology, Wright-Patterson Air Force Base, Ohio. R. H. Downing, A. M. Musgrove.

SYMANIK, EMIL F., Acting Department Head and Professor of English, Milwaukee School of Engineering, Milwaukee, Wis. K. O. Werwath, F. Kaufmann.

TABER, BOND, Assistant Professor of Geology, University of Alaska, College, Alaska. E. F. Rice, E. H. Beistline.

THURSTON, CLARK F., Assistant Professor of English, Pennsylvania State College, State College, Pa. R. E. McCord, V. E. Neilly.

TOONG, TAU-YI, Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge 39, Mass. J. Holt, J. Kaye.

TWIGG, JOHN F., Instructor in Graphics, Massachusetts Institute of Technology, Cambridge, Mass. S. A. Coons, J. W. Rule.

VIVIAN, J. EDWARD, Associate Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. T. K. Sherwood, W. K. Lewis.

VON STEENBURGH, RAYMOND V., Instructor in Drafting, Milwaukee School of Engineering, Milwaukee, Wis. F. J. Van Zeeland, F. Kaufmann.

WATSON, SAMUEL M., JR., Professor of Mechanical Engineering, Clemson Agricultural College, Clemson, S. C. B. E. Fernow, J. H. Sams.

WILKE, CHARLES R., Associate Professor of Chemical Engineering, University of California, Berkeley, Calif. T. Vermeulen, H. A. Johnson.

WILLIAMS, ROBERT D., Professor Emeritus of Psychology, Ohio State University, Columbus, Ohio. L. D. Jones, W. D. Turnbull.

WOODARD, HERBERT L., Executive Secretary, Colorado Society of Engineers, Inc., Denver, Colo. T. H. Evans, C. L. Eckel.

WU, CHUNG HUA, Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. E. L. Midgette, J. Modrovsky.

744 new members elected last year

TEACHING POSITIONS AVAILABLE

The following rules were adopted by the General Council of the ASEE:

1. The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE.

2. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

3. Advertisements should not specify salaries.

4. Advertisements must be submitted not later than the first day of the month preceding the month of issue.

5. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number.

6. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters.

7. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR OR ASSISTANT PROfessor of Electrical Engineering; M.S. desired with specialization in power; to teach machinery and circuits courses. Position available September, 1953. Send application to Chairman, Department of Engineering, State College Station, Fargo, North Dakota.

ASSISTANT OR ASSOCIATE PROFESsor of Metallurgical Engineering desired for September 1954 or earlier, to teach heat transfer and process metallurgy including thermodynamics. Advanced degree and experience essential. Drexel Institute of Technology, Philadelphia 4, Pennsylvania.

INSTRUCTOR OR ASSISTANT PROfessor in Applied Mechanics or Aeronautical Engineering. Prefer master's degree and some industrial experience. Apply to Professor M. Popovich, Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

INSTRUCTOR IN MECHANICAL ENgineering—Courses in Heat Power and Mechanical Engineering Laboratory. Opportunity for advancement. Apply to Prof. W. A. Vopat, Cooper Union, Cooper Square, New York 3, N. Y.

DIRECTOR OF THE DEPARTMENT OF Aeronautical Engineering, Parks College, East St. Louis, Illinois, Attractive salary and working conditions. SE–1

Keeping Abreast of Advancing Frontiers

A proposal for a new type of Summer Institute

By ARTHUR BRONWELL

Secretary of ASEE and Professor of Electrical Engineering, Northwestern University

Since 1927, the ASEE has sponsored summer schools for engineering teachers. These summer schools have dealt across the board with the subject matter in a given curriculum. For the most part, they have avoided detailed examination of subject matter in specific subject areas. These summer schools have proven highly successful in providing a forum for discussions relating to the broader aspects of the organization and development of curricular material, as well as the improvement of teaching methods. The summer school program has contributed in a very significant way to the improvement of teaching in engineering colleges and it should be continued in the future.

Experience has amply demonstrated that great strides in engineering are often made by reducing to practice new concepts of science and technology. Many areas of engineering education today, including much of electronics, chemical engineering, metallurgy, and engineering mechanics, were at the frontiers of pure science a generation ago. The process of assessment of subject matter, simplificaton for teaching purposes, and revision of engineering curricula has been a continuous one ever since the beginning of engineering education. It seems evident that at a time when science and technology are advancing at a more rapid rate than ever before, it is all the more imperative that this process of assessment and revision be continued. It is the responsibility of the engineer to assure maximum progress in the development of the art of engineering. The rate of progress of engineering depends in no small way upon the ability of the engineer to comprehend new advances in scientific and technological knowledge and to reduce these to engineering practice.

In the past fifteen years, there have been many instances in which substantial revisions in curricular subject matter have come about as a result of conferences of a comprehensive nature in specialized technical areas. In many cases, because of their highly specialized character, these conferences would not have been regarded as suitable for ASEE sponsored summer schools. But it was often this specialized character which made it possible to explore a restricted area with a high degree of penetration and to achieve therefrom a clarification of the underlying scientific and analytical principles. This is the first and most important stage in making an intelligent appraisal for curricular revision. This process of assessment of a new field, seeking out the fundamental concepts, and trying to determine, with a reasonable degree of balance, where and how it should fit into an already overcrowded curriculum is not an easy one. In this process, much can be gained by bringing the divergent viewpoints of the research engineer, the scientist, and the educator to bear upon the problem.

As an example of a technical conference which has exerted a profound influence upon undergraduate curricular organization, one can cite the conference on Advanced Electronics, held some years ago at the University of Michigan. This was an intensive investigation into what at that time constituted the frontiers of sci-

ence, including such subjects as gaseous discharge, energy states in atoms and behavior of electric charges in fields. This conference was instrumental in helping to produce a complete reorientation of the electronics curriculum along more fundamental lines.

During World War II, a seminar at MIT in an entirely new field, Ultra High Frequencies, resulted within a few years in a substantial revision of the undergraduate subject matter in communications and the introduction of Maxwell's equations as a fundamental basis of building concepts. For the first time, many electrical engineering teachers began to realize the extremely limited application of certain concepts which they had previously regarded as "extremely fundamental." Similar examples could no doubt be cited in numerous specialized areas of Civil Engineering, Mechanical Engineering, Chemical Engineering, and others where the technologies are moving rapidly ahead.

This situation raises the vital question, should ASEE develop a program of technical conferences which will penetrate more deeply into the frontiers of science and technology and which will evaluate, assess, determine interrelationships, and seek to revise curricula in accordance with modern needs? If we take the viewpoint that a deeper penetration into the more advanced technical areas is not the proper domain of ASEE, then it would follow that this function would revert to the technical engineering societies and it would be these societies, not ASEE, which would carve the future of engineering education. It seems evident that this role of assessing new areas of technology which are moving rapidly into modern engineering practice is one of the most vital functions of ASEE. It is the function which will determine whether engineering education will be dynamic or static.

This suggests the possibility of developing a forward-looking program of conferences, sponsored by the Divisions and Committees of ASEE. The purpose of these conferences would be to identify those areas of science and technology which are likely to be translated into significant engineering practice in the years ahead. The conferences would seek a deeper penetration of subject matter in order to clarify and systematize the underlying fundamental principles and evaluate them for teaching purposes. They would project ahead and seek to evaluate trends and probable future developments. They would also explore matters of organization of subject matter for teaching purposes as well as teaching methods.

Such conferences should be concerned only with those areas which are sufficiently fundamental in character as to merit serious consideration for undergraduate and graduate instruction purposes. The more specialized technical developments which do not open up whole new areas of fundamental principles are still the proper domain of the technical societies. However, there are promising possibilities of arranging conferences which seek to unify broad areas of the existing engineering curriculum. Such fields as heat flow, electric field theory, fluid flow, and vibration theory have a common base in their analytical methods. A conference seeking greater unity in the teaching methods in such fields might prove highly profitable.

This proposal was approved in general principle by the General Council of ASEE on June 26, 1953. The Council voted to authorize the appointment of a Committee of ASEE to study the proposal and take steps toward its implementation. The Council suggested that conferences of this nature should be a minimum of one week's duration. A number of engineering colleges have indicated their desire to sponsor such conferences jointly with the ASEE Divisions and provide campus facilities.

Several areas of possible future conferences have been suggested. These include: fundamental concepts of nuclear

transformations and nuclear energy; thermodynamics from the viewpoint of the physicist, the chemical engineer, and the mechanical engineer; solid state physics (including such subjects as transitors, metallography, etc.); unification in the teaching of analytical methods in heat flow, fluid flow, vibration, and electromagnetic theory; plastic flow in structures; and the teaching of advanced physics to engineering students.

It is clearly recognized that the scientific-technological stem is only one phase of engineering education and that a similar program should be developed for improvement of the social science and humanities courses. The Humanistic-Social Division of the Society has prepared a preliminary proposal for a comprehensive study in their areas and the Executive Board is currently working with the Division on its implementation.

Enlightenment is the first prerequisite to intelligent curriculum planning. By inaugurating this series of conferences, the ASEE hopes to stimulate soundly-conceived and forward-looking programs of curriculum planning which will contribute substantially to the advancement of engineering education.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Do You Know—

► Strictly personal—to young engineering teachers—this issue of the Journal contains the new rules for the YET Paper Contest. Last year's two prize-winning papers are published in this issue. Here is a distinctive opportunity to express your ideas and win national distinction. Good luck!

► This issue also contains a list of Chairmen of Divisions, Sections and Committees of the Society. General Council members are always listed on page two. If you are interested in submitting a paper for the June convention, please contact the appropriate Chairman.

► The Fall meetings of ASEE and ECPD, October 14–17 at New York opened up challenging new subjects. The ASEE program dealt with creative thinking. In the morning, a music critic and composer, Virgil Thompson; a painter, John Ferran and a literary man, Ralph Bates, dissected the subject of creative thinking from their respective viewpoints. A psychologist, Dr. Stein, presented a discussion of the mental processes involved in creative thought at lunch. Finally, two research administrators, Maurice Nelles of Borg-Warner and Fred Olsen of Olin Industries, tackled the subject from industry's viewpoint. This conference brought out some of the many challenging facets of this subject.

► A brief statement describing the George Westinghouse and Lamme awards is printed in this issue of the Journal. Brochures describing the awards more fully and nomination forms can be obtained from the Secretary. Nominations should be submitted before February 1, 1954, to the Chairman of the Award Committee.

► A statement by President Grinter on the proposal to increase the ASEE dues will be published in the November issue of the Journal. The September issue of the Journal carried the report of the Committee on Society Finances, the recommendations of which were adopted by the General Council last June. This issue contains the financial report and budget for next year.

The Society has only one staff member for every 1500 members. There is probably no other learned or professional society of comparable membership and scope of activities in the United States which operates with this small a headquarters staff. This is a tribute to the excellent work of the officers of the Divisions, Sections and Councils, who have accepted the responsibility for their part in the Society's operations. The Society has been successful in staving off deficits by devoting a great deal of effort to expanding membership, obtaining increased advertising and enlarging other sources of revenue. But this also entails added costs of operation which offset part of the increased income. It seems difficult to escape the fact that the dues per member today are worth little more than one-half of their value in 1946.

► The College-Industry Conference of the Relations With Industry Division will be held this year at the University of Detroit on January 16, 1954. The theme will deal with post-college education of the engineer. This conference presents subjects of widespread interest to industrialists and engineering educators.

► A great many platitudes have been eloquently delivered on the need for developing ingenuity and originality in engineering education, without sacrificing quality. Now we need a few concrete examples of teaching which achieves this objective. If you know of somebody who is doing an exceptional job, urge him to write it up for the Journal. These articles should be concise and to the point. Hold them down to two printed pages, so that we can include a number of different examples.

► Also, we need more *good* material on effective teaching techniques for our "Timely Tips" section of the Journal. These should preferably be directed at making difficult concepts sound simple. If you have something you would like to submit, send it to the Secretary. It should not exceed one or two printed pages; also, not too many photos please!

► A useful and revealing report of the ECAC Manpower Committee, projecting the supply of engineering graduates ahead and including the effects of ROTC, draft calls and returning veterans will be published in the November issue of the Journal. Watch for it.

► The Educational Methods Division has recommended that more emphasis be devoted to objective research in engineering education. This recommendation is worthy of serious consideration by the ASEE Divisions.

► If you have a notice of important ASEE activities for this section, in capsule form, please send it to me and we will try to get it into the Journal.

Best Regards,

ARTHUR BRONWELL, *Secretary*

College Notes

Gordon B. Carson has assumed the Deanship of the College of Engineering at **Ohio State University.** This position was formerly held by the late Charles E. MacQuigg, Past President of ASEE.

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Dr. Robert C. Disque, Dean of the Faculty and since 1933 Dean of the College of Engineering of **Drexel Institute of Technology,** retired August 31, and Professor Harry L. Bowman, head of the department of civil engineering, succeeded him in both posts.

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The American Society of Civil Engineers has announced the election of Daniel V. Terrell, of Lexington, Ky., as President. He is Dean of the College of Engineering, **University of Kentucky.** Dean Terrell, who will succeed Walter L. Huber of San Francisco, was installed Oct. 21 at the Society's annual meeting, held in the Statler Hotel, New York. He will serve one year.

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Professor Victor M. Ganzer has been appointed Executive Officer, Department of Aeronautical Engineering, **University of Washington.** He has been the acting head of the department during the past year following the resignation of Professor Fred Eastman because of ill health.

Improving the Product*

By LEE HARRISBERGER

Assistant Professor of Mechanical Engineering, University of Utah

When a young engineering instructor sets himself to the task of speaking about changes and improvements that he feels should be made in engineering education, he very soon wonders if he is not just a little pup barking at the heels of a stoic old St. Bernard. However, the greatest asset he has is a rip-roaring enthusiasm to try something new. It is also fortunate that this enthusiasm is undimmed by the conservative caution born of age and experience.

Every young instructor is prompted to crusade for improvement within his own college because of his natural revolt against the traditions and common practice that inevitably exist. He wants to change the text which has been in use for several years. He wants to write new laboratory experiments, buy new types of laboratory instruments and install new equipment. He thinks the classrooms ought to have better lighting and more demonstration equipment. He would like to see more faculty seminars and committees and an active promotion campaign for his college. As he grows older in the business of teaching, he sees that budgets do not permit sweeping improvements in laboratories and facilities, that seminars and committees are interruptions to a comfortable teaching routine. It is fortunate indeed that every faculty is subjected to a perennial crop of enthusiastic young instructors.

Because the young instructor is receptive to new ideas, he is for the most part a close reader of the journals and business magazines that publish articles of concern for the graduating engineer. Often he is selected to be the faculty chairman of the student engineering organizations and honorary fraternities. In these organizations, he enjoys a closer and more informal relationship with the student than many older faculty members enjoy. Students are quickly drawn toward a friendly association with a faculty member nearer their own age. Thus, they frequently volunteer their thoughts, opinions and criticisms of the faculty, the curriculum and its administration. In this environment of criticism from students, educators, technical associations and societies, and industry, the conscientious young instructor cannot help but feel that engineering education is not developing a product for the market.

Our engineering colleges are currently enjoying a "seller's market" and will for several years to come. Our senior engineering classes are entirely hired at "relatively fabulous" beginning salaries many weeks before graduation. This prosperity in the business world would not prompt too much concern over the quality of the product. Yet, even though industry is hiring our graduates with a starvation appetite, a great many industrial leaders as well as engineering educators and many of our students are voicing an increasing volley of comments about the competence of our graduates either technically, professionally or socially.

What are some of the things that are wrong with our production and our product? Louis Bromfield, in a recent magazine article, complains that colleges are granting degrees without education. Col-

* This paper won first prize in the Y.E.T. contest.

lege graduates are woefully lacking in grammatical competence, seriously limited in a broad interest of the arts, literature, or social problems. He states that spot surveys show that a very small percentage of university students are interested in an education—most are in college because of parental insistence, degree prestige, or because of the positions degrees will obtain.

The personnel director of a large industrial concern once commented before an engineering student body that his company was not interested in what the student had learned. He stated, much to the amusement of the students present, that everyone knew that the student was getting out-of-date information from out-of-date texts taught by out-of-date professors. His contention was that a degree in engineering merely signified that the student was capable of learning what his company was prepared to teach them. The main thing his company was concerned with was whether the candidate showed an ability to cooperate and get along with his associates.

Some of the larger companies have extensive training programs extending for several years to which they subject the new graduates. Some of the programs are linked with some of our graduate schools in engineering or have their own company-sponsored night schools. More and more we see the trend of industries involved in advanced research projects, such as rockets or atomic energy, in their hiring of new graduates. We find that they prefer graduates in physics or physical chemistry to engineers for their top technology positions. They are hiring engineering graduates for equipment application and design or production work. These activities and attitudes are a bold indication that our larger progressive industries give very little credit to our engineering colleges.

Among our colleges we find a concern for the type of course we offer. There is the concern that four years is not enough time. Some believe we should adopt a five year engineering course for a bachelor's degree. In some schools we find a trend toward generalization, eliminating several types of engineering and requiring more social and humanities courses. In other schools there is the trend toward more specialization. Many different degrees in engineering are being offered. There are combined programs offering a B.S. degree in engineering and a B.A. degree in business at the end of five years. There is the cooperative plan whereby an undergraduate is hired by a local company to work summers and part-time while he pursues his studies. All are attempts to close the widening gap between industrial demand and university product. Most, however, aim at the effect rather than the causes.

Educators are also showing their concern for the quality of the product by criticising the educational program. There is criticism of mathematics in engineering. One article commented that the list of courses in mathematics, almost universally required, has not changed in twenty-five years. A recent survey showed that most engineering students must repeat much of their high school mathematics. There has been criticism that there is too much redundancy in our courses in the treatment of physics fundamentals. There is comment that too much time is spent in trade courses such as drafting, surveying, and shopwork.

There is concern among educators for the faculty. Some feel that the faculty should do more research—bring in more contracts. Others feel that the faculty should spend more time on the business of teaching. The American Society for Engineering Education recently appointed a national committee to study means of encouraging faculty members to turn their energies to improving their teaching. Faculty members are being encouraged to obtain advanced degrees. Other educators feel that engineering faculties should encourage industry to provide them with summer work and on-the-spot periodical industrial indoctrination.

Every member of an engineering faculty

can testify that the methods of teaching within engineering courses are to a large degree "by-the-seat-of-the-pants." Most of us learned to conduct a class by remembering how our own classes were taught and by following the advice of our elders. We improved only by experience at the cost to the students. It is a rare case indeed that a member of an engineering faculty has any formal training in the aspects of teaching. As a result we find that our courses are canned, our examples are often idealized, the content is filled with repetition and childish drill, our lectures often show our mastery of the complicated and little thought for the difficulty of comprehension. We direct the student in his thought processes. We make him lean on us. Our examinations encourage memory and signify the end of a trial.

Even though science has expanded one thousand fold, our curriculum has not changed enough since the beginning of the century. Our student is subjected to a four-year routine in which he is told to take a prescribed list of courses in a prescribed order. In most cases he is allowed only his choice of a few hours of electives, sometimes less than 10% of his credit. Our efforts to balance sections and faculty loads each term to a large extent dictate when the student will section his courses.

We find that our students have for the most part become slaves to credit. It is a natural tendency to "beat-the-rap" when subjected to a dictated routine. The student's concern is to get his required number of hours for his degree with the least amount of effort. He complains frequently that laboratory courses do not have enough credit. He frequently petitions for credit for any practical experience he may have gained in part-time employment. In general, he is seeking a degree rather than an education.

Basically, then, our problem is one of trying to develop a flexible educational program which not only meets the demands of technology today but one which will continue to keep up with the terrific advancement ahead. It must include a program of development for the staff. Above all, it must create an environment for the student which will develop confidence in his training, a mature professional attitude, and a thirst for learning.

Now, what is needed for the production of a graduate that will meet the demands of the market? We need to provide a much broader background in the expanding area of scientific fundamentals. We must install an extended field in the applied mathematical language of science. We need a program of self-initiated undergraduate research and design. We need a program of "free-seminars" which would encourage thoughts and ideas both in technical and nontechnical areas. We need stronger preparation in the high schools. We need a closer working relationship between education and industry. This is a tall order but one that must be met entirely, not just partially.

This program would inevitably necessitate a major upheavel of our entire present system of engineering education. It would require a revision of the methods and philosophies of every instructor. It would call for a revision of approach and content of each system of courses in all our service departments such as Mathematics, Physics, and Chemistry. It would even lead to a revision of the role our high schools and preparatory schools play in pre-college training.

Many good schemes have been proposed by various educators recently for developing one or more of the desired aspects. A need such as outlined here must incorporate the best of many of these proposals. It is not the purpose of this paper to develop the operational and functional details necessary to revamp a typical college of engineering. It is doubtful that one person could. However, a general philosophy of the scope of operation necessary to fulfill the purpose can be outlined.

We first must initiate within the secondary schools a mature preparatory course

for pre-engineering students. That is, we must very definitely specify and demand a raw product that will meet the requirements our system of education will make. We must give back to the secondary schools the elementary foundation courses of our first years in engineering and insist that their graduates meet our standards. Much of our first year in engineering is spent re-teaching every course taken in high school, such as algebra, trigonometry, mechanical drawing, chemistry, physics, English and grammar, and the social sciences. Redundancy and inefficiency are cell mates.

The first major criticism here would be that too many students come from small rural schools where they could not get this sort of training. Here is where the sectional junior colleges would play their role. No institution is better equipped to be an engineering college preparatory school. The high school students who could not meet the entrance requirements in engineering would enroll in a junior college for the deficiencies.

With the freshman year's subjects virtually eliminated from the curriculum, the way is clear to devote two full years to a much extended foundation in engineering science. The way is clear to begin mathematics with analytics and calculus the first year. During the second year an advanced applied mathematics course covering such items as Fourier Series, Laplace Transform, Statistical Analysis, Nomograms, and Differential Equations should be offered. The student would be taking advanced physics and chemistry including nuclear physics the first year. During the second year, revised foundation courses in applied engineering science should be introduced, such as: courses in mechanics, thermodynamics, electricity and electronics, fluid mechanics, metallurgy, etc. All of these courses should be devoid of the techniques of specialized design applications. The student should be placed in a position to learn to understand the association of the basic laws to the field. He should not be made to feel that his success depends on how well he has memorized the techniques of applying the developed formulas.

During the first two years, there should be time for the addition of courses which develop the capacity of the mind to cope with ideas both philosophically and geometrically. Practical courses in philosophy, psychology, logic and reasoning along with descriptive geometry, speech, technical writing, and elements of visual presentation through charts, graphs, symbols, curve plotting and tabulation should be available. The curriculum would necessarily be specified for the student during these two years with the exception of possibly 15% of his credits allotted to non-technical electives.

This general outline of curriculum content for the first two years illustrates one important point. The student would be subjected to a mature diet of the fundamentals of science and reasoning. These courses would be taught with the idea that the most important thing for the student is to acquire the ability to reason and analyze. It is important to notice that no mention was made of the breakdown into specialties or options. The fundamentals taught are common to all branches of application.

Following these two years of basic preparation would be the period of maturity for the student. During the junior and senior years the student would be given a great deal of freedom. There would be no specified curriculum, no specified number of credit hours required for each term. Only general requirements would be met. That is, the student would be required to meet a credit requirement for these two years which would include a certain percentage in his major, a certain percentage in a minor and a certain percentage within a broad field of non-technical humanities or cultural courses. Whatever curriculum he would follow would be one of his choosing as approved by his counselor.

The student's major should be selected within three general areas. Professor

King of U.C.L.A. proposed a very good plan for the designation of these areas of specialization: technical research, production and design, and sales or management. For example, students selecting the general major of technical research would plan a series of courses in a field of advanced technology with, say, 60% of his credits devoted to advanced courses in basic sciences and his minor interest, 25% of his credits devoted to self-initiated research projects and seminar participation and 15% to cultural subjects. In the production and design area he would devote, for example, 70% of his credits to his major and minor, 15% to self-initiated design projects, and 15% to humanities. In the management or sales area, a breakdown could be made whereby he devotes 45% of his credits to an engineering major, 40% to courses in management, business, and engineering economics, and 15% to humanities. In all cases the student should be encouraged to avail himself of the most knowledge he can possibly acquire during the time he is in college. All students should be advised to carry all that the "traffic will bear." The brilliant student should not be inhibited by restrictions in number of hours he must carry at any one time. Initiative and industriousness should be encouraged.

It is obvious that the freedom allotted to the student will set up a natural system of gravitation. Each student will gravitate to a level according to his ability. Those who set out to achieve the highest degree of accomplishment in coverage of a chosen field should be awarded some recognition on their degree.

With all students developing their own curriculums it would appear that scheduling and assignment of classes by various departments would be impossible. Critics would proclaim that sectioning would be thrown into chaos. Not necessarily so. At some advanced date the college could require that each student post his course intentions for the next two terms. The schedule for each term would be built around the demand. The innovation here is that the college will schedule its courses for the student instead of scheduling the student for its courses.

The prime requisite of our graduate to meet our ever expanding technology is confidence in his background and mature judgment in his approach to his future. The proposal here is aimed at just that. The student will only grow in confidence and maturity when put to the task. He must see that the responsibility for his training lies entirely with himself. His mastery of his field was founded on his own choice of curriculum and his own initiative in its performance. Assigned schedules, cook book courses, and directed study reduce the student to robot performance and sub-normal attainment.

Freedom of schedule is one large step toward this goal. However the classroom training must be consistant with the aim. Instructors must revise their lecture techniques to eliminate time consuming drill chores. Their courses should inspire curiosity and encourage the student to "go the second mile." Tight schedules of presentation should be eliminated. The content and coverage should be geared to the class demand and always inspiring them to greater heights.

Each engineering college should develop a sound system of in-service training for its faculty. Regular seminars on the improvement of teaching should be required. This sort of thing would be the saving and making of many young instructors and the re-vitalizing of the old timers. These sessions would encourage a uniform philosophy of classroom approach, introduce new lecture techniques and discourage habit-bound lecturers. The faculty should be encouraged to work on advanced degrees. More important is a workable system of encouraging faculty members to work in industry frequently. The scientific competence of the faculty is necessarily important but within many areas of engineering his up-to-date knowledge of the practicing profession is equally as important. It is a sad thing indeed

for a faculty member to direct the activities of a student to prepare him to step into industry with confidence when he himself has not been associated with the field for twenty years.

Finally the student should be assigned to a faculty member during his first term at the college. The counselor would play the role of his "great white father." He would be recognized by the student as his friend, advisor, confidant and inspirator during his entire college career. The faculty's greatest contribution to the successful attainment of the students' engineering endeavor while in college can be made in this capacity.

College Notes

The Iowa Institute of Hydraulic Research at the **State University of Iowa** announces the recent publication of the Proceedings of the Fifth Hydraulics Conference which took place June 9–11, 1952. This Bulletin, No. 34, is devoted entirely to the manifold problems of transport, scour deposition, and measurement of sediment. Contained in this Bulletin are fourteen papers contributed by experts on various phases of this topic, and discussions by those who attended the Conference.

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A program allowing civil engineering students to get a head start toward advanced degrees in law, business and public administration, or regional planning was introduced at **Cornell University** in September. Formerly, after completing Cornell's five-year civil engineering course, a student spent three more years for the law degree or two years for the master's degree in the other fields. Under the new program with the Law School, School of Business and Public Administration, and College of Architecture, a student may obtain both degrees a year sooner. Students will begin the combined program in the fifth year of engineering school by choosing elective courses acceptable to the chosen division and other courses that meet requirements in both areas.

Errata

In the September issue of the JOURNAL OF ENGINEERING EDUCATION under "College Notes" it was stated that a grant of $150.00 to the University of Pittsburgh by the Westinghouse Educational Foundation was made. The grant was for $150,000.

Education for the Engineering Spectrum

By RALPH J. SMITH

Professor and Head, Engineering Department, San José State College

SYNOPSIS

There is an obvious need for improvement in engineering education to keep pace with the growth of engineering. In meeting the need we can raise the entrance requirements, increase the length of the program or reduce the number of objectives per student. By recognizing that engineering is a broad spectrum of activities and organizing our programs to reflect functional preparation, we can provide improved training in line with the requirements of engineering and the aptitudes of students.

In his report on "The Year of Evaluation" Dean Hollister pointed out that engineering curricula have been modified very little in the last forty years. He proposed that we examine carefully our present standard engineering program to determine whether it will serve the coming needs in engineering education. The purpose of this paper is to point out one serious problem facing engineering education, indicate the possible solutions, and suggest how the best solution can be accomplished.

The Problem

We are all aware of the tremendous growth of engineering knowledge and activities. There is an obvious need for improvement in our system of engineering education to keep pace with the growth of engineering. In the past we have attempted to take care of this problem by the introduction of specialization. We split off mechanical engineering from civil engineering, electrical from mechanical engineering and electronics from electrical engineering. In each case we were recognizing the fact that with the growth of engineering the fraction of the total which one man can master becomes smaller and smaller.

Along with the growth of technical knowledge there has been a repeated call for increased breadth of engineering training. We list a tremendous number of objectives for engineering education. Our graduates are to be fully aware of the tradition of past engineering accomplishments, trained in current engineering practice and prepared for keeping up with engineering progress for the next fifty years. They are to have the capacity to design on the highest technical level and to be skilled in human relations with an understanding of the principles of business organization and management. They are to have breadth of training in several engineering fields and, in addition, to possess the specialized knowledge required in their own field of specialization. They are to be proficient in all modes of expression—verbal, graphical and mathematical. On top of all of this we expect them to have a broad education in the humanities. The problem is, how can we set up our engineering training programs to provide an ever increasing number of qualified graduates to meet the ever enlarging demands?

* Second prize winning paper in the Young Engineering Teachers Competition, presented at the Annual Meeting ASEE, Univ. of Florida.

Possible Solutions

There are at least three approaches to the solution of this problem: we can raise the entrance requirements, increase the length of the program, or reduce the number of objectives per student, as suggested by L. E. Grinter.

Raise the entrance requirements

By being more restrictive we can limit entrance into engineering colleges to superior students. These students would be selected on the basis of their ability to learn rapidly and on their demonstrated aptitude for scientific study. This would permit increasing the accomplishment in four years.

An obvious disadvantage of this approach is that we would effectively reduce the number of engineers available. This is directly contrary to the conditions of the problem. Not only do we have a present shortage, but there is need for a steadily increasing number of engineers. As a matter of fact, we must increase the percentage of the total population who are qualified along technical and scientific lines. Any elevation of the entrance requirements would have the opposite result.

Increase the length of the college program

Another possibility would be to go to five- and six-year programs. Assuming, for example, that there is fifty per cent more to be learned, perhaps students should expect to spend fifty per cent more time in college. Would this mean that in another forty years we should go to an eight-year program? Obviously this doesn't make sense.

A college can fill effectively only a certain limited portion of a young man's life. That period is bounded on one side by the fact that to benefit from college instruction a student must have sufficient maturity to set up goals and work on his own initiative. At the other boundary is his psychological need to be gainfully employed, to get married, to start a family and take his place as a contributing member of society. The present four-year period seems to be consistent with the psychological, economic and sociological factors.

Reduce the number of objectives per student

This is an approach which we make use of frequently in engineering. If we wish a device to be efficient we limit the performance expected of it. A general purpose device is usually characterized by being complex, bulky and expensive. The introduction of subject-matter specialization in engineering programs is an illustration of this type of approach. However, it appears that this type of subdivision has reached the point of diminishing returns. There is another approach which, in my opinion, holds great promise. This is specialization by function.

Functional Classification

The classification of engineering into *fields* of chemical, civil, electrical, mechanical, mining and petroleum engineering is in terms of what the engineer works *with*. From the standpoint of training, a much more meaningful subdivision is by *function* which is related to what an engineer *does*. The major engineering functions are: research, development, design, construction, production, industrial, operation (and maintenance), application (and sales), and management.

Research

The research engineer is seeking new knowledge or a better understanding of known facts. He is seeking new principles, new methods, new processes, new truths. He is working on the frontier of scientific knowledge and his training must provide a thorough understanding of advanced mathematical and scientific concepts. He must have the ability to reason inductively and in abstract terms, and to express himself in new mathematical forms. He should be skilled in analysis.

Development

The job of the development engineer is to apply the discoveries and results of re-

search to some useful purpose. He uses the principles, tools and techniques made available through research. His efforts usually result in a working model of a circuit or process or machine which has desirable characteristics. The development engineer must be ingenious and creative. He should be skilled in experimentation. He must have great initiative and perseverance.

Design

The design engineer takes the result of the development engineer and carries it to the point where it is economically useful. He designs products so that they can be manufactured and sold at a profit. His work consists of: selecting methods of accomplishing desired results; investigating processes and devices to perform intended functions; selecting materials and determining shapes to satisfy physical, chemical, electrical and thermal requirements. The design engineer must have advanced training in the properties and behavior of materials and processes and the ability to adapt recent advances to current practice. He must be skilled in synthesis. He must be proficient in graphical expression and have a strong background in economy.

Construction

The construction engineer is responsible for surveying the site and preparing the location for the structure. He determines the procedures to be followed on the basis of economy and desired quality of the result. He directs the assembly, placing and joining of materials. He organizes the personnel to carry out these operations. The construction engineer must be skilled in the art of his profession. He must be able to direct people effectively and have a firm grasp of costs.

Production

The work of the production engineer closely parallels the construction function except that it is concerned primarily with products constructed in a factory or other fixed location to be operated elsewhere. He chooses the processes of manufacture, the sequences, the tools, and the methods. He integrates the flow of materials and components with processes. He provides inspection and testing facilities and procedures. He eliminates bottlenecks and corrects faults in manufacturing procedures. He works closely with designers through early stages of production and participates in redesign.

Industrial

The industrial engineer works closely with the Production Engineer and frequently there is some overlapping. He works with the Production Engineer in selecting equipment and laying out the plant, in so far as human and economic factors are concerned. He devises jigs and fixtures and work stations which facilitate human effort and increase production. He writes job descriptions and makes job evaluations. He makes time studies, sets standards and rates of pay and designs incentive pay systems. He operates cost controls, supervises clerical procedures and forecasts production costs under new conditions. The industrial engineer is primarily concerned with the economic and human factors in production and his training and personal qualifications must be suitable.

Operation and Maintenance

The operating engineer controls machines, plants or organizations which provide services such as power, utilities, transportation, communication or storage. He is responsible for the selection, installation and maintenance of equipment. As the supervisor of an over-all manufacturing operation he is sometimes called the plant engineer. He is responsible for preventive maintenance programs and the operation of complex equipment for maximum economy. He determines operating procedures and supervises operating personnel.

Application and Sales

The application engineer analyzes customers' requirements and selects and rec-

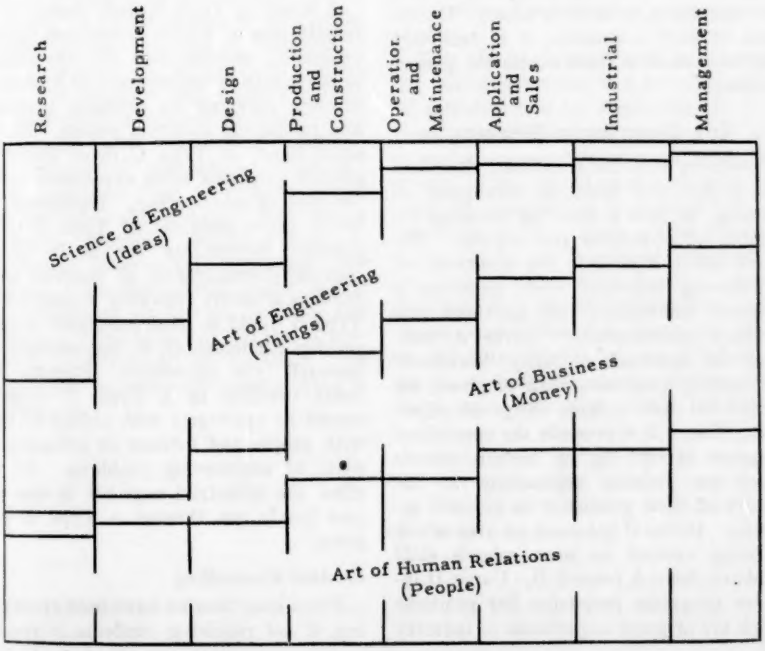
ommends units to satisfy their specifications most economically. He combines salesmanship with technical education and training in application. He analyzes customers' complaints and trains the customers' operating personnel. He must be able to deal with persons at all technical levels from the maintenance man to the research scientist. The application engineer must be skilled in verbal expression and have a strong business training.

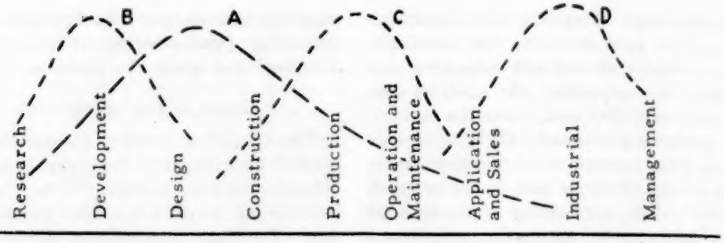
Management

It is the responsibility of management to determine the main purposes of an enterprise and to set up the policies to be followed. The manager sets up the form of organization, the chain of authority and selects the executive personnel. Engineers have proven valuable in management positions because of their ability in analyzing the factors involved in a problem, collecting the necessary data and drawing sound conclusions. The primary requirements include a background of engineering fundamentals, skill in human relations and ability in business.

Engineering Activities

The foregoing detailed discussion is included here because the functional classification is more meaningful to a student attempting to plan a career in engineering. The basic requirements for engineering are aptitude, training and interest. Interest is usually associated with *field* of engineering, while aptitude and training are more closely associated with *function*. The requirements for work in the production, say, of electric motors, are almost exactly the same as those for the production of internal combustion engines. The design of a bridge requires nearly the same training as does the design of an airplane fuselage. The operation of a refinery involves the same problems as the operation of a steam power generating plant.





In general, engineers work with "ideas" (abstract scientific concepts and principles), "things" (machines, materials, structures, circuits), "people" (supervisory and personal relations) and "money" (costs, investments, profit, interest). The extent to which engineers in various positions employ knowledge in the four areas is indicated roughly in the chart below. If this approach is valid, then there is a second reason why the functional classification is desirable from the standpoint of training. Early in his college training the student should be able to decide whether he prefers to work with ideas, or machines and equipment, or men, or money. On the basis of such a decision, it is relatively easy to counsel a student into the proper training.

The Engineering Spectrum

Assuming that the functional classification is desirable from the standpoint of training, we have a basis for reducing the number of objectives per student. The above chart illustrates the spectrum of engineering activities, each requiring a different combination of aptitudes and personal qualifications. Curve A indicates the approach of many "standard" engineering programs with emphasis on design but with a wide range of objectives. Curve B represents the specialized program carried on by certain schools which are building reputations on the quality of their graduates in creative activities. Curve C indicates an area which is being vacated as some schools shift emphasis from A toward B. Curve D includes programs preparing for positions which are of great importance to industry but which frequently go unaccredited because of their lack of "design emphasis." There are, of course, no sharp lines of demarcation between these activities. Since these are but subdivisions of engineering, in all programs there will be a common core of scientific fundamentals, technology, basic skills and humanistic-social studies. However, programs preparing for different areas of the spectrum should have certain distinguishing characteristics in their faculty, equipment, student selection and course objectives.

Distinguishing Characteristics

A school of Type B must choose for its faculty men of ability in research and development, creative men who are anxious to contribute to the advance of knowledge through carrying on research programs and publishing scientific papers. On the other hand, in Type C there should be greater emphasis upon experience in the practice of engineering. Equipment selected for a program of Type C would provide opportunity for study of the over-all characteristics of complex units, whereas students following a program of Type B would be more interested in engineering fundamentals as demonstrated by research type apparatus. Perhaps students enrolled in a Type D program should be extroverts with ability to work with people and interest in economic aspects of engineering problems. All too often the industrial engineer is one who just barely got through a Type A program.

Student Counselling

For a long time we have been encouraging, if not requiring, students to special-

ize by field. We have worked hard at determining whether students were qualified for engineering training on the assumption that engineering is a single activity rather than a broad spectrum of activities. It is not to be expected that one type of training would be best for all functions, nor that one type of individual would be equally suited to all functions, nor that one type of training would be best for all individuals. There must be more attention paid to evaluating students' abilities along the lines previously indicated. Probably the first two years of engineering programs should continue to be pretty well standardized. During that time there should be opportunity for a student and his counsellor to decide on a desirable functional specialization.

Responsibility of the Schools

Each school must determine what its role in engineering education is to be. Obviously there will be considerable overlapping. However, each school should have its objectives clearly in mind instead of trying to be all things to all people. Certain schools will find it desirable to offer more than one program in a given field. For example, one western university now offers programs in construction engineering, civil engineering (design) and engineering mechanics (research). These programs deal to a large extent with the same subject matter, engineering structures. However, there is a clear differentiation between faculty, courses and students. Another school might decide that in terms of its faculty, facilities and location, a combination of a Type B program in electrical engineering and a Type D program in mechanical engineering is desirable, say.

It will be necessary to reorganize some course offerings. For example, in the past it has been customary to offer "thermodynamics for electrical engineers." Obviously the electrical engineer doing design needs exactly the same training in heat transfer as does the mechanical engineer doing design. What we need are courses in "thermodynamics for design engineers" and "thermodynamics for operating engineers." We need "electrical engineering for research" and frequently this is available—in the physics department. The important thing is that there must be a more critical approach to organization of programs, curricula and courses.

Conclusion

In engineering education we face the difficult task of preparing our graduates for a field which has progressed rapidly and promises to continue that progress at an ever-accelerating rate. In my opinion, the best approach to our common problem is to reduce the number of objectives per student.

This can be accomplished by recognizing that engineering is a broad spectrum of activities and by employing the functional classification of engineering as a basis for organization of engineering programs. Each school must determine just what its contribution in engineering education is to be. Each school must set down clearly the functional objectives of its various programs. Faculty, courses, facilities and student counselling procedures must reflect the chosen objectives. It will be a difficult job but it offers one means whereby engineering education can keep pace with engineering technology.

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1954).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at the University of Illinois, June 17, 1954.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 25 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences.
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1954. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1954.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

Engineering Education and Engineer-in-Training Examinations

The following papers were presented at the ECAC General Session on June 25, 1953 at the University of Florida, Gainesville, Florida.

1. Dean J. H. Lampe, North Carolina State College, Introduction and Outline for the Problem.
2. Professor C. S. Crouse, University of Kentucky, One Viewpoint of This Problem.
3. Dean Roy M. Green, University of Nebraska, Another Viewpoint of This Problem.

Opening Statement by Dean J. H. Lampe, North Carolina State College, Introducing the Discussion

Professional recognition is the abstract goal sought by the engineering profession and by practically every man who has reached the level where others tender to him the title Professional Engineer. This recognition may well be called our most persistent yearning—a yearning of long standing.

There were probably two principal reasons for the creation of Engineers Council for Professional Development twenty-one years ago. First, there was a deep concern because of the large number of young men entering the initial educational programs and a relatively few developing into real engineers. Second, there was a deep-seated yearning on the part of engineers that other well-informed men recognize us as truly professional men.

To study these matters systematically and to suggest actions to improve the situation, ECPD promptly set up four principal committees or divisions: (1) Student Selection and Guidance, (2) Engineering Schools, (3) Professional Training, and (4) Professional Recognition.

For convenience these four specific committees were neatly titled and identified, but the problems these committees studied were inter-related. It may therefore be said that every engineer, no matter what his position may be, has a real interest and a real stake in the deliberations and actions of each and all of the four committees.

Throughout its life ECPD has had as two of its participating bodies the National Council of State Boards of Engineering Examiners and the American Society for Engineering Education. Throughout the history of these two groups there has been an interlocking of interests and a sharing of problems. Both have been equally concerned with the goal of professional recognition.

The intimacy of their relationship is well illustrated by the wording of the Model Law for the registration of professional engineers. The definition of a professional engineer is one "who, by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience, is qualified to practice engineering." As minimum evidence of qualifications for registration the law further provides "graduation in an approved engineering curriculum of four years or more from a

school or college approved by the Board as of satisfactory standing; and a specific record of an additional four years or more of experience in engineering work of a character satisfactory to the Board, *and indicating that the applicant is competent to practice engineering.*" Provisions to this general effect are in practically all state laws, although there is an occasional variation in the years of required experience.

At a conference in 1943 representatives of ten national engineering organizations approved several amendments of the Model Law as perfected in 1937. In the last edition of the Model Law (1946, page 6) is the following statement, "All amendments were adopted unanimously, the most significant being the insertion of provisions whereby the examination for professional engineers may be taken in two parts—the first at the time of graduation in an approved engineering curriculum, or upon evidence of attainment of the equivalent, with respect to fundamental engineering subjects, at which time those successfully passing this portion of the professional examination may be provided with certificates designating them as engineers-in-training, to whom it is expected that after four years of active practice the second part of the examination will be given, the successful passing of which will permit them to become professional engineers."

Either the propriety or the efficacy of the engineer-in-training examination as a registration procedure to be applied to graduates of "approved" schools has often been questioned. The practice of giving such examinations has grown very rapidly since 1943. If the giving of such examinations is unsound practice, a movement should be initiated to reverse the trend. If the practice is wise and justifiable, it should be promptly expanded to every state in the United States. Our program today is intended to bring this question before the Society for discussion.

In order that the discussion may be focused only upon the question, the speakers have agreed to the following three statements.

1. The sole purpose of registration laws is to "safeguard life, health, and property and to promote the public welfare."

2. Examining boards have no legal or moral right to expand their activity beyond the administration of the laws as written and within the geographical boundaries of their legal jurisdiction.

3. It is the duty of each board to register all applicants who are competent to practice professional engineering and to refuse registration to those who are incompetent. The time at which such competence must be determined by the board is the time at which a certificate is issued to practice professional engineering.

One Viewpoint of This Problem

By C. S. CROUSE

Professor and Head, Mining and Metallurgical Engineering, University of Kentucky

I have been asked to talk about the Engineer-in-Training program and the relationship of this program to engineering education. As a matter of fact this constitutes but one phase of the Registration movement which includes the effect of professional licensing on engineering curricula also. It therefore seems advisable to take a general look at the picture and to present some historical background before discussing the particular as set out in the agenda.

State licensing of any sort and this includes that of Professional Engineers is based legally on one thing and one thing only, the police powers of the State.

This must never be lost sight of as all phases of the laws involved, all rules and regulations that Licensing Boards may set up are null and void unless they can be definitely tied in, in a logical way, to these police powers, in other words to the health and safety of the public.

This statement undoubtedly entails a definition or an interpretation of what can logically and legally affect the health and safety of the public. In the last analysis this will have to be determined by court decisions which quite likely will vary somewhat through the different states. But until such data is obtained, and it is not available in any amount as yet, the individual State Boards are having to make their own interpretations and distinctions.

Two Schools of Thought

In this regard there seems to be two distinct schools of thought; a very literal interpretation and one that is perhaps somewhat more liberal but still within the framework of the law. In the first case it might be held that only those who are involved in engineering work that can be shown to very directly affect the public would need to be licensed. In the more general and to my mind the more logical interpretation, anything that an engineer may do professionally somewhere and in some way touches upon the health and safety of the public. My remarks will be predicated upon this concept.

At the present time there are engineering licensing laws in effect in all of the 48 states, in the three Territories of Hawaii, Alaska, and Puerto Rico, and in the District of Columbia. These laws are administered by legally appointed Boards and each one is entirely autonomous in its actions and must of course act within the framework of the particular state law involved.

However, most of the laws, in addition to the savings provision or so-called Grandfather's Clause, embody or have embodied two main ways in which licensing might be obtained. One of these is that registration may be given to a candidate who can show graduation from an accredited engineering curriculum and a minimum period of years, usually four, of qualifying experience satisfactory to the Board. In the other case the candidate must show a minimum of usually eight years of satisfactory qualifying experience, five of which might be while obtaining his education, and successfully pass a written or a written and oral examination.

As time went on many states, for one reason or another, amended their laws so as to eliminate registration through graduation and experience only thus requiring the successful passage of a written or written and oral examination in practically all cases before licensing would be allowed. This situation exists in about fifty per cent of the States today.

This trend has had a definite effect on engineering education entailing as it does a reconciling of view point, where necessary, between the engineer who is teaching and the engineer in the field. I think that the implications are self evident but not too directly concerned with the Engineer-in-Training program.

Manifestly, although the only legal justification for licensing pertains to the health and safety of the public, nevertheless there are certain corollary effects which have had their effect on the Profession. Among these has been the undoubted better understanding of and respect for the Profession by the public as a whole, a better understanding of what engineering is and of what engineers are, both within and without the profession, in brief, the attainment of a truly professional status. In addition, and quite possibly even more important, there has been inculcated into the engineers themselves a better understanding of the intangibles of professional ethics and a true professional consciousness.

As the Registration movement grew it became incumbent upon the various State Boards to determine which curricula and which engineering colleges would be considered as having accreditation status with

that Board. I deem it self evident that the necessary investigation prior to such accreditation by the individual State Boards of all of the engineering curricula in the United States posed a monumental problem and if carried on on that basis would lead to inequities due to varying criteria.

No Other Alternative

However, lacking any other procedure, the various State Boards were left with no other alternative than to attempt the practically impossible, New York doing an excellent piece of work in this respect.

As more and more of the States passed licensing laws this procedure became more complex and more onerous and costly both to the Boards and to the schools involved and lead inevitably to the conclusion that what was needed was an engineering agency to investigate and accredit engineering curricula. As a result Engineer's Council for Professional Development was formed with one of its major objectives the development of a fair and impartial method for the evaluation of the minimum requirements of an engineering curriculum which would make that curriculum subject to accreditation. The constituent bodies of E.C.P.D. were and still are: the four Founder Societies, the American Institute of Chemical Engineers, the Engineering Institute of Canada, the National Council of State Boards of Engineering Examiners, and our own Society.

E.C.P.D. divided the country into zones, the constituent Societies appointed engineers from among whom the actual accreditation committees could be chosen and the work got under way. This was to all intents and purposes the first time that an attempt, on this scale at least, had been made to view engineering education nationally with a somewhat uniform set of minimum standards. In some institutions the result of the procedure was scarcely felt; in others it caused a re-evaluation of objectives and in others the impact was terrific.

It can be readily seen, then, that legal licensing with its demand for accreditation which resulted in the founding or formation of E.C.P.D. and its accreditation program has had, and, I believe, will continue to have a far reaching effect on engineering education.

Again with the passage of time a new element entered the picture. The developments in the fundamental sciences of Physics and Chemistry to name but two were and are rapid and drastic. When developed into engineering techniques, these, in many instances caused the introduction of undergraduate curricula of considerable specialization. This proliferation of so-called "fringe curricula" and the pressure from the schools put upon the Education Committee of E.C.P.D. for their inspection and probable accreditation presented a problem which is not yet wholly solved. To further complicate an already complicated situation various of the State Registration Boards began to look askance at some of the curricula accredited by E.C.P.D. as not being of sufficient caliber to properly train an engineer at least according to the definitions of these Boards. This in turn presented a serious threat to the whole accreditation procedure with the ultimate result, if the trend continued, of throwing the procedure back into the near chaos of individual Board accreditation.

This problem has definitely worked back into the Colleges; in fact they have in no small degree been responsible for its creation, and its effect upon engineering education has certainly already been felt and in my opinion will be felt even more in the future.

During the same time that proliferation of engineering curricula was taking place the developments in the fundamental sciences already spoken of were happening even more rapidly. This made it quite apparent that, if the engineer were to be properly trained in his profession, the basic science foundation of an engineering curriculum must be increased with a consequent use of more

time in a fixed time curriculum for fundamentals and consequently less time for specialization. Certainly these two trends were antithetical.

The Executive Committee of E.C.P.D. had discussed this situation at a number of meetings and finally appointed a Committee on the Adequacy and Standards of Engineering Education with Past President Hollister as Chairman. There were three other members of this committee of which I was one but Dean Hollister did the work. The report of this committee was rather widely publicized and I believe has had and will have some effect.

After the publication of this report, E.C.P.D. felt that the work should be continued with a broader scope and asked our Society to take over, the result being the formation of Dean Grinter's committee on the Evaluation of Engineering Education. This committee went right to work and is reporting at this meeting.

In what I have said so far I may appear to have wandered from my assigned subject but, if I have, it has been with purpose, as I do not believe that persons more or less unfamiliar with what has been going on specifically in the very interrelated and rather complexly intertwined developments coming from the Registration Boards, the E.C.P.D., the Engineering Colleges and from our own Society, can grasp the true significance of the problem without the overall picture.

The so called Engineer-in-Training program, and it is quite possible that a better name could be found for it, is only comparatively a few years old. In many States it is quite a lusty child; in others it is aborning and in others it is not yet conceived.

What is the program; why was it developed; and how does it justify its existence both legally and otherwise as well; and how has it or may it affect engineering education are all questions of importance and ones that I will attempt to answer briefly against the backdrop already painted.

Graduation Does Not Make an Engineer

I think everyone will acknowledge that the mere graduation from an engineering curriculum does not make an engineer. Adequate experience in some phase of engineering practice is fully as important as the acquisition of technical knowledge. In most States, if not in all, an engineering graduate cannot legally be considered for license until he has secured a minimum of four years of qualifying experience satisfactory to the Board and often it takes a considerably longer experience time record than the minimum. Briefly the Board must be satisfied and the time record cannot be less than the minimum but it can be and often is greater.

This means, then, that under the most favorable conditions there is a hiatus of four years between graduation and legal recognition. This gap has been recognized for years by the Founder Societies in their qualifications for full membership.

In the past and unfortunately in many instances today the engineering colleges have had a tendency to turn their graduates loose, except for some aid in finding the initial position, and left them to sink or swim with little or no guidance in this critical period of their careers. At the same time two of the things that might help the man in this phase of his development, a true professional consciousness and a thorough concept of professional ethics, may be lacking as most undergraduate curricula do not stress these, to my mind, essential subjects in an engineer's training.

With legal licensing being a prerequisite to professional practice anywhere in the United States, one of the first and most important objectives of the young graduate is to qualify for registration as soon as possible. This means in turn that he must secure the proper kind of qualifying experience and, when that is acquired, must, in most States, pass a written examination.

These examinations are, on the average, of two days' duration, the first day being designed to ascertain the candidate's

knowledge of what is usually given in an undergraduate engineering curriculum with the emphasis on fundamentals and the second day attempting to determine what he has been taught by his experience. A man upon graduation could not hope to pass the second-day examination because he would not have had the experience background, and it is becoming increasingly difficult for the man with experience alone to pass the first part because he has not had the necessary formal education.

The problem of the young engineer in the interim between graduation and the attainment of professional recognition is two-fold. First he should be integrated into the profession as rapidly as possible, and secondly, and this is probably a part of the first problem, he should be guided in such a manner as to acquire the minimum qualifications for licensing as early as is legally possible.

It has been said by some that the Engineer-in-Training Program cannot be legally justified on the basis of the police powers of the State. I take exception to this viewpoint as a too narrow interpretation of the facts. I hold that anything that tends to make a man a more competent engineer directly affects or in time will affect the health and safety of the public. This is true not only during the young man's training prior to licensing but more particularly is it applicable after he has obtained registration and the legal status of a professional engineer. In my opinion the Engineer-in-Training Program has this effect.

Recognizing the situation outlined and feeling strongly that something should be done about it, several of the State Boards a number of years ago established what they called the Engineer-in-Training Program. The objectives of this program were to earmark, as it were, the young graduate for the engineering profession by in some way publicly labelling him as one working toward professional status. At the same time it was expected that this would help the individual's own morale and develop his professional integrity and competence more rapidly.

It is evident that the State Boards, as such, could do little to actually aid the man in his apprentice period but they definitely could label him so that the professional engineers with whom he might come into contact could take over.

The next question was as to how to apply this label and the solution worked out was to offer, and I want to emphasize that word offer, the young man about to graduate or immediately after graduation the opportunity to take an examination designed to show his competency in the fundamentals of an engineering education. If the man passed this examination he was then to be given a certificate stating that he had passed such an examination and that he was qualified as an Engineer-in-Training by the particular State Board involved. Please note that nowhere in the procedure is there any compulsion and that the certificate issued has no legal significance whatever.

The idea of the program and the procedures worked out to implement it took hold rather rapidly so that at this time many of the State Boards have inaugurated the program and others are considering it. In some States the program was authorized by legislative amendment to the existing law; in others through regulations of the Board.

Details Vary

The details of the plan vary somewhat as between States, which is to be expected, but in general the Engineer-in-Training examination is a written one of eight hours' duration based on the fundamentals usually taught in a four-year engineering curriculum. The cost of taking the examination varies from about three to five dollars with, in some cases, this fee being credited to the subsequent examination for licensing. As the program developed, so also did the feeling that some procedure should be worked out whereby a man might receive credit for his Engineer-in-Training status as be-

tween States. The result has been that most of the States now recognize the Engineer-in-Training examination of the other States and will give credit for it up to eight hours on the examination for professional licensing. In other words if a man has passed an Engineer-in-Training examination in one State he will be given credit for one day of the professional examination by most of the other States that have the program.

That the efforts of the State Boards along this line have the hearty support of the young engineering graduate is evidenced by the increase in numbers taking the examination. When a young man about to graduate or recently graduated from an engineering curriculum is not only willing but anxious to pay from three to five dollars for the privilege of working hard for eight hours, he must feel that what he receives, if the passes, is well worth the effort.

What has been the overall effect of the development of this program? It may be divided into two parts; the effect upon the individual and upon the profession and the production of better qualified engineers; and the effect upon engineering education. The first effect has proved to be rather definite already; the second more nebulous becoming increasingly more definitive as shown by the interest at this meeting.

I have said that the licensing Boards as such could do little more than attempt to label a man for the profession, the full effect both individually and professionally resting upon the interest and work of other agencies. These agencies, many of them, have taken up the challenge and are doing yeoman work.

E.C.P.D. was among the first to tackle the job and the work of the Monteith Committee resulting in the Monteith report was outstanding. However, the scope of the procedure as outlined in the report was such that it could not be implemented immediately. Neither the necessary funds nor the personnel were available. However, a great deal of extremely constructive work has been and is being done along the lines laid down in the report, and this not only through the efforts of E.C.P.D. alone but also with the cooperation of many other agencies and of Industry.

The results on the individual have been many not the least of which has been the easing of his integration into the social, civic and professional life of the community through the thoughtful interest taken in him by outside agencies and individuals. At the same time there has been a very definite and tangible effect as shown by the fact that, in many instances, governmental agencies and industry as well are definitely paying higher salaries for exactly the same work to those holding certificates as Engineers in Training than to those who do not hold such a certificate.

The effect on engineering education is evidenced in two directions; on the graduate program and on the undergraduate program.

In the former case it applies largely to those schools located in industrial centers which can offer night courses in advanced phases of engineering. Here the effort being made is to make it easy for the young graduate to continue his formal education while he at the same time is making his living. Both Industry and the Colleges in these areas are cooperating to further this objective. More can be done in this field in the way of offering well worked out extension courses either with or without College credit and through the arranging of periodic lectures and conferences given by outstanding men in various fields. This phase of the program for the up-grading of the young engineering graduate is already being emphasized in various areas, the work along this line being done in Canada being especially noteworthy.

Impact

The impact of the Engineer-in-Training Program on the undergraduate curriculum has not yet been felt to any great extent with the possible exception of a

few locations in which the program has been in existence for a considerable period of time. This is due, I think, to a number of reasons, not the least of which is the opinion of some Deans and engineering teachers that there is not and cannot be any connection between the two. In these cases the curriculum and teaching seem to be sacrosanct and any failure on the part of the young graduate to pass his Engineer-in-Training examination is due to the examination itself and not to the man's scholastic background.

I would be the last to claim that any examination is perfect; I have been teaching too long for that, and I feel strongly that written examinations are but one of a number of criteria that should be used to judge of a man's qualifications. Nevertheless, I firmly believe that when an examination such as that for an Engineer-in-Training has been well considered, has stood the test of repetition, and when students from some schools average good grades and these from others not so good, then it must mean something in so far as the undergraduate preparation of the individual taking the examination is concerned. Again, when students in a given institution average consistently good grades in some areas and consistently poor ones in others, I would consider it only the part of wisdom to inquire into preparation, method of teaching and course content in those fields in which student preparation seems to be the poorest.

No one should take an ostrich-like attitude and bury his head in the sand because sooner or later it will cause a rude awakening. Rather, I am sure, the truly constructive attitude is to examine the results of these examinations over a long enough period of time so that it may be done statistically and then, if any definite trends are shown, try to remedy any faults that may be found. This is especially true as between different Colleges the graduates of which are taking the same examination and as between different Department within a given College where definite weakness may appear.

In some States where the program has been under way for a considerable period, study has shown that the graduates from certain of the institutions in those States do far better than those from other institutions and those that do better do not necessarily come from the more widely known schools. If such information could be made available, it should prove of great benefit to the administrative officers of the schools involved. No individual or school is so perfect that improvement cannot be made.

I have personally made some rough statistical appraisals of the results in my own State and I have no hesitancy in saying that some trends have been found. What they may mean is quite another question but I firmly believe that if an honest conscientious effort to find the answer or answers is made and, if the answer appears to be unfavorable and then the same sort of effort is made to correct the situation, the impact of the Engineer-in-Training program upon undergraduate curricula and instruction may be very great indeed. If we have a yard stick, even an imperfect one, by which we can in part measure the effect of what we are trying to do, we should by all means use it even though the results may prove embarrassing. If we can find the trouble, we should be able to correct it.

It is hard to conceive of a man with four years of training getting a flat zero in the physics section or the mathematics section of an examination while the most of those taking the same examination have passed these sections creditably. Yet this has happened not once but a number of times. Should such a man be graduated with a Bachelor's degree in Engineering? Personally I doubt it. And yet this individual is probably more sinned against than sinning. Somewhere down the line someone has slipped up because such a man should never have been allowed to reach the Senior year, let alone graduate.

Yes, in my opinion, there is a very definite interrelation between the Engineer-in-Training program and engineering education. It is definitely incumbent

upon those of us engineers who are employed in the teaching branch of the profession to use any means at hand to improve our theory and practice, and I feel sure that a careful, intelligent study of the results of Engineers-in-Training examinations is one of these means. If this is done constructively and impartially, letting the chips fall where they may, I cannot help but feel that great good will result therefrom.

Parenthetically it should be stated that so far as the mechanics of the operation are concerned most of the State Boards are working rather closely with the faculties of the engineering colleges within their respective States in the preparation, administration, and evaluation of the Engineer-in-Training Examinations.

In what I have said I have tried to logically show how and why the Engineer-in-Training program was developed; the beneficial effect that it has had and is having upon the individual, the profession and the public; and the effect that it has had and, I believe, will increasingly have on engineering education.

Controversial Subject

It is unquestionably a controversial subject upon which I have expressed my own views only. What I have said I firmly believe. If I have been able to give you, however briefly, some background information on the subject so that you may more reasonably and logically arrive at your own conclusions, I will consider that the time and effort put into the preparation of this talk to have been well spent and that the objectives that I have had in mind while writing it will have been accomplished.

We are all working toward the same end, the production of a better product. Anything that will tend to promote this is well worth investigating. We cannot expect unanimity of opinion, nor would such be desirable. I feel that anything that will promote honest discussion and intelligent thought will constitute a forward step in the attainment of our objective. I sincerely hope that our program this morning will do just that thing.

Another Viewpoint of This Problem

By ROY M. GREEN

Dean, College of Engineering and Architecture, University of Nebraska

Organizations such as the American Society for Engineering Education are brought into being and continue to exist because their members feel a professional responsibility. Through such organizations the hope is held by the members that they may meet these responsibilities more adequately. Most of the members of our Society have an individual responsibility both as professional engineers and as professional educators. Our members are anxious to discharge their professional obligations.

For clear thinking we should consider in specific and complete terms exactly what we mean by a profession—what we mean by the engineering profession.

A profession is worthy of that designation only when it fulfills the following four conditions:

First, it must have a mission, a goal, an ideal for which it strives. The goal of the engineering profession is that of creating better and more plentiful facilities for the use and convenience of mankind.

Second, it must perpetually strive to extend the body of knowledge which is its particular responsibility and upon which its professional practice is based.

Those who practice a profession are special guardians of the area of knowledge involved in their work. As the profession grows stronger, this knowledge should become more exact and cover more thoroughly the matters involved. Therefore, a significant number of men in the group should be productive research workers. They should question the validity of every assumption made in practice and every method of engineering analysis.

Third, if there is a profession, its members must share their knowledge with each other. Advances made by one person or group should be made available to all other persons who may be able to use them in a professional way. It is by this sharing of knowledge that ideas are tested for validity and practicality. After being tested, these ideas are then ready to be added to the available resources the profession has to offer in advancing its mission.

Fourth, no profession actually exists unless mankind in general is permitted to enjoy the benefits of the special knowledge possessed and used by the practitioners. The abundance of facilities available to the average citizen in the United States attests to the fact that engineers have shared the rewards of their special knowledge. The engineer not only turns the forces of nature to the benefit of mankind, but he does it economically and thereby produces an abundance in many areas where scarcity previously existed.

Function of Registration

By emphasizing these four steps, engineering has become a strong and respected profession. Out stature as a profession is established through our dedication to these four principles. Registration or non-registration has absolutely no influence on our stature as a profession and but very little effect upon our true status among well-informed men. What, then, is the function of registration? Why is it important?

The sole purpose of a registration law is to "safeguard life, health, and property and to promote the public welfare" and this is the declared objective as stated in some form or other in all our registration laws. A board which uses the statute for any other purpose violates the law. A board member is not appointed to represent his profession, but is rather a *professional representative* of the public. An examining board is authorized and appointed in the public interest to "regulate the practice of engineering."

It is the board's duty to register all applicants who are competent to practice professional engineering and to refuse registration to those who are incompetent. The time at which competence *must be determined by the board is the time at which the certificate is issued or denied.* The evidence collected by an examining board must be conclusive on the date of such issuance or denial. Evidence collected by giving engineer-in-training examinations at graduation time, if justifiable, must be part of this conclusive evidence three or four years later, for most laws require from three to four years' experience following graduation before a certificate to practice may be issued. Our only questions at issue then are these: Does the EIT examination provide a necessary part of conclusive evidence of competence at the time of registration? Do EIT examinations furnish the best evidence of an adequate educational background? Is requiring an EIT examination a wise and considerate treatment of the young men we expect to develop into professional men?

Proponents of the EIT examination argue that the test should be given at the time of graduation because the applicant can pass it more readily at that time. (Report of 1949 NCSBEE, page 108). I know of no one who will deny this is the time examinations, such as are now given, are most readily passed. If this be true, however, the board is gathering irrelevant information upon which to decide whether to issue or deny a certificate four years later, because the graduate will forget just as many of the details of his

technical knowledge whether he did or did not take such an examination at the time of graduation.

The proceedings of the twenty-sixth annual meeting of the National Council of State Boards of Engineering Examiners held in New York City in 1947 contains a report of the Committee on Engineers-in-Training. In that report is the following statement: "The majority of the Committee feels that written examinations should be required of all candidates before certification as Engineers-in-Training for the following reasons:

"(1) There is a wide difference in the technical ability of graduates. The minimum requirements for graduation and for certification as an Engineer-in-Training are set by independent organizations and need not necessarily coincide.

"(2) Many graduates have no intention of ever becoming registered professional engineers, or even practicing the profession of engineering. They intend to be technically trained businessmen, or go into administrative work.

"(3) It will cheapen the registration movement in the eyes of the young engineer, to give him status as an Engineer-in-Training without any effort on his part."

The reasons given for EIT examinations as listed above are interesting. We would all agree that the abilities of graduates vary, and that the standards for graduation and for certification as Engineers-in-Training need not be the same. I find no justification, however, for a different standard unless there is evidence that the EIT standard indicates competence to practice professional engineering four years later.

We would agree that some graduates do not intend to practice engineering. It is difficult for me to see any connection with this statement and the question of giving EIT examinations. If the statement is an inference that planning for other than a professional engineering career shows inferiority on the part of any young man, it is high time that someone requests proof of such an inference.

The third reason given in the report seems strange. That is that "It will cheapen the registration movement in the eyes of the young engineer, to give him status as an Engineer-in-Training without any effort on his part."

Artificial Barrier

Is it assumed that the young engineer made no effort in earning his degree? If the standing of the registration movement "in the eyes of the young engineer" is dependent upon clearing an artificial barrier created by older members of the profession, the whole movement will, and should, fall of its own dead weight. Do we create a lasting respect by demanding artificial sacrifice of time that could be used more beneficially in developing better men? In many states engineering societies are conducting coaching schools to encourage and aid young graduates in reviewing their college work. The sole purpose of this effort is directed toward passing these examinations. We then have the queer situation where one segment of the profession is designing an artificial barrier for entrance to practice, and another group showing how to get over it. It would appear that a much more beneficial professional service could be performed if these assisting groups would help in the process of professional development in a realistic sense by encouraging the graduates to be more effective practicing engineers along the lines of the four professional criteria mentioned in earlier parts of this discussion.

At the same meeting in 1947 (page 69 of the *Proceedings*), Dean W. N. Dougherty, among other things, had this to say, "I debate seriously as a member of an examining board that has been writing questions for 26 years whether or not that series of examinations can be validated at all with the performance of engineers registered within 26 years. We assume our examination is the kind of thing that everybody should take. It hasn't been

validated, what makes us believe as engineers that we can give an examination that will indicate qualification to practice engineering?"

Dean Dougherty's statement was answered most directly by Mr. D. B. Steinman of New York. Part of his answer was given in the *Proceedings* as follows: "Dean Dougherty asks whether we can prove a correlation between the passing of an examination and professional success. That question is not asked by the lawyers or doctors. They have settled that question long ago, and the examination is the *mandatory* entrance requirement into the profession."

Apparently neither the Committee nor the advocates of EIT examinations claim the examination is a test of whether the applicant is competent to practice professional engineering. Is such a procedure right just because the doctors and lawyers use it? Is the practice of law like the practice of medicine? Is the practice of engineering like either? Should the engineering profession attempt to solve its own problems or simply ape some other group?

Some states require the Engineer-in-Training to take another written examination in professional engineering four years after graduation, at which time a certificate to practice is issued if the applicant passes the examination. Other states simply issue a certificate of registration after the young engineer has had four years of experience "satisfactory to the board."

Professional Development

The development of a professional man is dependent upon continuing the learning and study process. A person who may fail the EIT examinations while in school and continues to develop by extending himself as an engineering learner is likely to be a much better engineer four years after graduation than one who passes the examination and then becomes a reluctant participant in the learning process. Hence the EIT examination, in some instances, becomes an artificial barrier without significance in the determination of ability to practice engineering.

Boards should examine each engineer as he is actually practicing his profession and not as he may become by going through a cramming process for six months or six days. Such college-course examinations are not logical tools to use in determining competence for practicing engineering. The design of *strictly professional engineering examinations is extremely difficult.* The development of such a discriminating method of professional appraisal is, however, the responsibility which has been assumed by each examining board.

The definition of a "professional engineer" as given in the last published model law is "a person who, by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design acquired by professional education and practical experience, is qualified to practice engineering." Earlier model laws defined a "Professional engineer" as "a person who, by reason of his knowledge of mathematics, the physical sciences and the principles of engineering gained by education and experience, is qualified to engage in engineering practice." Most of our laws contain one or the other of these provisions, thus rightly requiring evidence of some educational background in mathematics, physical science, and principles of engineering. The question, therefore, is, does an eight-hour examination give better evidence of this educational background than the transcript from an accredited engineering school? The transcript represents the composite judgment of many examiners accumulated over a period of four years or more. Further, the transcript is a very detailed report with a subject-field coverage which is more complete than any eight-hour examination could possibly contemplate. To me the transcript constitutes better evidence of an educational background than a single examination.

In 1937 E.C.P.D. began the arduous

task of accrediting curricula leading to engineering degrees. This accreditation program, while not perfectly satisfactory, has been continued with very commendable results. The task of school visitation and inspection was undertaken at the urgent request of the majority of the professional engineering societies and associations, including our own. The organization which was most vigorous in promoting the E.C.P.D. accrediting program was the National Council of State Boards of Engineering Examiners, and the Council has always appointed representatives upon the delegatory inspection groups. It is illogical that this group should continue to advocate and take part in such accreditation programs and then assume that they must retest the product which has already been tested many times in the educational process which they have already approved. It is frankly admitted that some other groups, such as the legal and medical professions, have done the same thing in the past. Previous use of this device by others does not make the process any more logical or justifiable.

In some states the Engineer-in-Training examinations are prepared and graded by the same teachers who have also taught the students and given them their course work and examinations. Are we to assume that such teachers are more intelligent or careful when they perform such work for an examining board than when they conduct their regular work? Are we to assume these teachers know more about the students' background of knowledge by giving a single examination than through a series of class sessions, tests, problem assignments, and final examinations? Are we to assume that only those teachers selected by examining boards are competent to pass upon the students' ability?

The giving of an EIT examination at the time of graduation is, in my opinion, an inconsiderate financial treatment of the young men involved. The various states charge a fee of from $3 to $15 for such examinations. If the examinee moves to another state, he loses the fee and is obliged to pay the full amount when final registration is achieved in another state to which he may move. Since more than half of our college graduates in engineering are in a different state when final registration is achieved, the student simply loses his money. This loss is at a time when young men can least afford to throw away money.

Conclusion

It is respectfully urged that we, as professional men, take steps to alter the trend of giving Engineer-in-Training examinations to graduates from accredited schools. The first step in such a proposal would be for our organization to request that the model law be rewritten, deleting the portion relating to EIT examinations. The second step would be to ask for a joint meeting of representatives of the American Society for Engineering Education and the National Council of State Boards of Engineering Examiners. This joint committee could work toward closer cooperation in the development of a positive method of joint action with a view of preserving the ideal of professional identity for the young graduate during his first few years following graduation.

The Technician and the Engineer*

By C. J. FREUND

Dean, College of Engineering, University of Detroit

The Detroit Edison Company is building a 600,000 kilowatt generating station at St. Clair, Michigan. This is one of two new stations which the company is projecting to supply the constantly expanding needs of Detroit's residents and industries. The St. Clair project is in charge of my good friend Mr. Al Pasini, national vice president of the American Society of Mechanical Engineers.

Very many engineers work directly under Pasini; others cooperate with him. The engineers are associated either with the Detroit Edison Company, or with manufacturers of machinery or equipment, or with contractors doing construction work. They are concerned with the design of buildings, foundations, turbines, generators, boilers, condensers, switchgear and the like. They make decisions on the ground when problems arise which are not covered by prints and specifications.

At the same time, great numbers of technical men on this job are not professional engineers. They are technicians. They direct construction and erecting operations, inspect materials and finished work, and install and test machinery and apparatus. They are the superintendents, foremen, inspectors.

Once the plant is completed, other technicians called stationary engineers will have charge of its daily and regular operation. Professional engineers will stand by, and solve technological problems, design improvements and plan changes.

It is quite true that the functions of engineers and technicians overlap in practice. Engineers in one plant or corporation perform tasks which technicians perform in another plant or corporation. But the theoretical line of demarcation is clear enough.

The engineer understands principles and fundamentals of mathematics, physics and chemistry. He uses his knowledge in research, design and development. The technician likewise knows mathematics, physics and chemistry. But he uses his knowledge to perform calculations, run tests, make estimates and prepare diagrams.

The engineer plans; the technician makes and does. The engineer creates and projects; the technician operates. Of course, there are exceptions. Not all technicians are operators. Many of them assist engineers in creating and planning. They are the draftsmen, estimators, testers, research technologists.

The technician is concerned principally with how to do it. The engineer is concerned principally with why to do it. It is common for the technician to be more competent in the doing than the engineer. For instance, a land surveyor should be handier with a transit than a civil engineer.

In general, the technician is auxiliary to the engineer. This must be clear if the relation of the technician to the engineer is to be understood. Some technical institute people have occasionally been annoyed by mention of this auxiliary status as implying some kind of dishonorable inferiority. In my view, there is no real basis for this feeling and I believe it is disappearing. After all, we have higher anl lower orders throughout our social

* Technical Institute Division, ASEE, University of Florida, June 23, 1953.

and industrial organization. There is nothing dishonorable about being a first class machinist and not a foreman; there is nothing dishonorable about being a superintendent and not a works manager; there is nothing dishonorable about being a salesman and not a sales manager; or a nurse and not a surgeon; or a high school teacher and not the principal; or a sergeant and not a commissioned officer; or a son and not his father and head of the family. There is nothing dishonorable, I hope, about being the dean of a college of engineering and not the president of the university.

If the auxiliary relation of the technician to the engineer is not understood and accepted, there is no chance, in my opinion, for the proper development of technical institutes. Of course, there are in the United States no fixed occupational classifications. Any technician can become an engineer by meeting the well known qualifications.

It seems to me that a most significant feature in the relation of technicians to engineers is simply this: the vast majority of engineers don't understand the function of the technician; and don't realize that technicians, as well as engineers, are in short supply. Indeed, the shortage of technicians is doubtless much more serious than the shortage of engineers, only we don't think and talk about it.

Consider a typical engineer who has a drawing to make, a test to run or some other technician job to do. If a technician is at hand, the engineer gives him the task. If no technician is available, the engineer gives the work to a young engineer, or he does it himself.

The engineer should not do technician work himself. He should spend his time doing his own proper work. You will never catch a surgeon doing nurses' work. It is permissible for a young engineer to perform a certain amount of technician work by way of training and experience. But after he has acquired training and experience, he should not have to perform technician tasks because there are no technicians around. Still more important, he should not spend his whole life doing technician tasks. And too many engineers do just that.

In spite of the serious shortage of technicians, and the fact that too many engineers spend much of their time on technician assignments, I suspect that 90% of engineers never give thought to the education of technicians. I further suspect that 90% don't even know that the technical institute is the proper educational institution for the preparation of technicians.

The engineering profession in the United States ought to be informed about technical institute education. The most effective means of doing this, I should think, is to tell the story directly to engineers. Why should not technical institute men appear in programs of the Founder and other great national engineering societies? Why should not technical institute men publish accounts of their aims and their work in the journals of the engineering profession?

All of us have the habit of telling our story to ourselves. For example, business men meet and tell each other about free enterprise. It would do more good if they told their story before a convention of socialists. In the meeting of the A.S.E.E. at Seattle in 1950, a visitor to the session on cooperative education remarked on the excellence of the program, but said that it should have been presented before the National Association of Manufacturers. Many fine talks before the Technical Institute Division of A.S.E.E. might better have been presented before the American Society of Mechanical Engineers, or the American Society for Metals.

I am today merely a representative of the engineering profession, and I fully realize that I am not as well informed as others concerning technical institutes. However, I feel it would not be out of place for me to recommend that the Technical Institute Division of A.S.E.E. consider whether it should not make the education of us engineers a most important project of the next four or five years.

Reports of the Vice-Presidents

Annual Report of the Engineering College Administrative Council, July 1, 1952-July 1, 1953

Executive Committee Meetings

Four executive committee meetings were scheduled by Chairman Lampe during the year, the first two on September 4 and September 5 at the time of the Centennial of Progress, the third at the Statler Hotel in Washington, D. C., on November 12, 1952, and the fourth at the Illini Center in Chicago on February 20, 1953.

The September 4th meeting was devoted entirely to a consideration of the problems originating with the new Air Force ROTC program. A number of guests were invited including representatives of the Air Force led by General Deichelman. Out of the meeting a better understanding of the objectives of the new program was obtained and the results of the discussion were circulated by means of the *ECAC Bulletin* of October 7.

The meeting of September 5 dealt largely with the organization and plans for the operation of the committees.

The meeting of November 12 was a special session primarily for those members attending the Convention of the Association of Land-Grant Colleges and Universities, and was devoted to continued planning of committee activity and preliminary planning of the program at Gainesville. In addition, the agenda for a meeting to be held the following day with representatives of the Mutual Security Administration and the Technical Cooperation Administration were discussed.

At the February 20 meeting, final completion of the program at Gainesville was accomplished. The growth of the organization known as the Engineers and Scientists of America was discussed and it was agreed that President Woolrich should be invited to prepare a statement to acquaint engineering deans with the growth and plans of this organization. Reports of committee projects of the year were given. An important program was the review of the Army and Air Force ROTC developments which took not only the form of the special meeting of September 4 and the subsequent dissemination of the discussion, but also several meetings in Washington with representatives of the Army and Air Force officers attended by the Chairman of the Military Affairs Committee, Dean William Allen, the Chairman of the Council, Dean J. H. Lampe, and the President of the Society, Dean Woolrich.

Projects of the Year

On November 13 the joint meeting of the ASEE with the representatives of the Mutual Security Agency and Technical Cooperation Administration was held at the State Department and was presided over by Chairman Lampe. As a result of this meeting a new committee of the Engineering College Administrative Council was appointed by Dean Lampe which will be advisory to the MSA and TCA. The chairman of this committee is R. A. Morgen. A meeting of this committee was held on February 16. It was particularly emphasized that all approaches by MSA-TCA to individual faculty members should be through their deans rather than directly and arrangements were made for the submission of possible candidates by deans to the chairman.

Dean Pierce of the Committee on Relations with Secondary Schools has been developing cooperation with the American Mathematical Association and the National Council of Teachers of Mathematics, in a proposed study of High School-College articulation in the field of mathematics. Representatives of all the groups involved met at Atlantic City April 10 and 11. Dean Pierce was authorized by the Executive Council to cooperate in the planning and to attempt to secure funds from a Foundation for the implementation of such a program.

News Bulletins

ECAC News Bulletins were circulated three times to our institutional, associate and affiliate members, and to the ASEE officers and council members.

Programs

The Engineering College Administrative Council has also developed programs for two national meetings. The first was held in connection with the Centennial on Engineering on Friday afternoon, September 5 and was presided over by Chairman Lampe. The topic was "1920–1952: What Are the Contemporary Demands on Engineering Curricula." The panel included five speakers, one for each of the areas represented by the Founder Societies.

The Council sponsored several sessions at the annual meeting at Gainesville including:

1. a general session on Thursday morning,
2. a joint conference with the Mathematics Division on Wednesday afternoon,
3. a program by the International Committee on Tuesday afternoon on "Cooperation with Engineering Education in Other Lands,"
4. the always popular International dinner on Tuesday evening, and
5. the Friday Executive Session for Institutional Representatives.

Respectfully submitted,
J. H. LAMPE, *Chairman*
W. L. EVERITT, *Secretary*

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

PRESIDENCY VACANT AT SOUTH DAKOTA SCHOOL OF MINES AND TECHnology, Rapid City, South Dakota, a school offering bachelor's and master's degrees in engineering and science only. Applicants must have Ph.D. degree in engineering, academic engineering and administrative engineering experience. Faculty of 60. Contact Eric Heidepriem, Regent of Education, Custer, South Dakota.

INSTRUCTOR OR ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING (Power). At least B.E.E. required. Appointment immediately or February, 1954. Apply to Dean, School of Engineering, University of Virginia, Charlottesville, Virginia.

Annual Report of Engineering College Research Council

The last year has seen the continued growth of research and development in the United States to a point where both money spent and people engaged in research exceed any previously recorded figures. The engineering colleges have shared in this growth. It is now estimated that something over $3 billion is being spent in the United States each year on research and development. This growth of research in government was greatly stimulated by World War II and it was during this period that the military department began to appropriate large sums for these purposes.

In the fiscal year ending July 1, 1952, the Government spent $1.84 billion for research and appropriations were even higher than this. It is expected that expenditures will amount to $2.1 billion in the fiscal year ending June 30, 1953, and in the two following years there will be a leveling off at about 2.2 billion and 2.3 billion dollars respectively. Of these amounts, it is possible to identify that being spent in non-profit organizations (colleges, research foundations, etc.), and apparently about $72 million is being spent by the Federal Government in non-profit organizations for basic research. In addition it is spending about $175 million for what is called applied research, and about $75 million is being spent for engineering and development purposes. In 1951 about $23 million was spent on plant and facilities by these non-profit organizations and this figure fell to $20 million in 1952.

It appears that the amount of money being appropriated by industry from its own funds for research and development has reached a temporary plateau for it has remained somewhere between $1.2 billion and $1.3 billion for the last three years. In addition to the funds cited above, which come from the Federal Government, engineering colleges are doing research for industry as well as performing some basic research with their own funds. The magnitude of these funds is more difficult to identify. The amount of work being done by universities in general has increased about $20 million per year for the last five years; so, at the present time, total funds available in universities for research and development are approximately $280 million. Obviously a large fraction of this total originates in the Federal Government and many colleges are becoming quite apprehensive of the effects of cuts in the Federal research and development program. Since Federal funds must be divided between three large customers, of which the smallest share goes to universities, little actual savings can be realized by cutting the universities' shore. On the other hand, there are reasons for concern because industrial laboratory research sponsored by the Military is often closely tied to production contracts and contracts for pilot models and tooling which, in all probability, will have to continue. Much Government research is done in government-owned establishments which have no other function and which are often founded on large and expensive facilities, such as proving grounds and wind tunnels. These must be maintained for national security. With both industry and Government laboratories having a priority on a portion of the Government's research dollar, colleges wonder if they might not be cut much more than they are prepared to accept. Unfortunately, many colleges have made commitments to staff and build-

ing programs which cannot be abrogated and which would represent a real burden if the colleges were expected to finance them alone.

Shift in College Research

There has been a noticeable shift in college research from development, and even engineering, to the more basic kinds. The Department of Defense has helped in this regard by setting up special offices to encourage and help support such research. The Office of Naval Research of the Navy Department is well known in this respect and it has been joined more recently by the Office of Ordnance Research of the Department of Army and the Scientific Research Office of the Air Force. All three of these organizations are now making grants for the support of basic research. The National Science Foundation not only makes grants for research but also supports fellowships in Engineering Sciences. However, rightly or wrongly, none of the grants made by these four organizations cover the total and complete costs of the research. Although the first three pay an overhead based on an audit of the college's expenses and the last allows a fixed percentage on the sum of the grant which does not differ from college to college, the engineering schools themselves must recognize that in taking on such contracts, or accepting such grants, they undertake some additional financial obligation. However, if these grants are regarded as seed corn to stimulate research or as a method by which the college can multiply the effect of funds it has from its own resources for research, the result can only be counted as a good one.

The Engineering College Research Council recognizes and is pleased with the activities of these organizations in trying to stimulate research in some small schools and in areas which do not have a tradition of creative thinking in engineering. By strengthening these areas and these schools, all of the engineering colleges are strengthened.

Again the engineering colleges, in a spirit of self-examination, are beginning to question why they indulge in development work and even in engineering. It is fairly obvious that in times of national emergency the colleges must devote themselves to the more practical aspects of science. Unless it is admitted that we are to live in a continual state of emergency, this reason has long since ceased to exist. On the other hand, there are some clear thinkers in education who say that engineering schools must continue to do some engineering work. Their line of reasoning is something like this:

We now expect all of our engineering teachers to be at the forefront of scientific knowledge. This requires they be familiar with the research that is going on in their particular fields. Second, we contend that engineering is a practical science and engineering teachers, in order not to mislead their students, must know how things are done in the engineering profession. Third, and most important of all, engineering by its very nature is a creative profession and therefore an engineering teacher must not only understand science but must know how to do engineering in a creative way. Where is he going to get the necessary experience and where is he to practice his engineering? Obviously he can do it by consulting, and although this helps him both as a professional man as well as financially, few if any benefits accrue from such labor to his principal employer, the engineering school. For many years, medical schools have been closely associated with hospitals and clinics where the professional staff can practice its profession. Is not this a practice which should be followed by engineering schools? Should not all schools have departments of Engineering Research, institutes, or engineering experiment stations in which the staff itself can practice engineering? Lastly, in this practice of engineering, will it not be possible to assist Government and industry, and especially small industries, to get a start on engineering programs? While doing this, is it not possi-

ble to combine the science and education of engineering and also support graduate students financially while providing them with the instruction in research which is so necessary for advance degrees? Although a committee of the Engineering College Research Council is still groping with these thoughts and trying to formulate them in an understandable manner, it is hoped before long they can be issued as a policy which can be advanced for adoption by the Research Council itself.

Too Few Graduate Students

It is believed by most engineering college research workers that the number of graduate students now in our schools of engineering is far too few. This is brought about by two factors: first, the generous salaries now being paid our graduates by industry who need them as quickly as possible to add to their engineering strength and, second, by the few and relatively low paid fellowships and opportunities for earning available for graduate students. The grants being made by the Department of Defense agencies have been a tremendous help in alleviating this need, but more must be done by industry if we are to have a continuous and sufficient flow of men with advanced degrees into the engineering profession.

The Engineering College Research Council is cognizant of the tremendous opportunity it has in rendering service to the small business of the country. Big business needs no selling on the advantages of conducting a virile research program and in applying the results of that research to their products. Many small industries have never tried this, either because they feel they cannot finance such a program, because they do not know how to start a program of research, or because they are not familiar with its benefits. This too is a field of opportunity in which the Engineering College Research Council has not yet formulated its plans and on which it hopes to do something within the next year.

The committee of the Engineering College Research Council which has worked hardest is that under the direction of Mr. Raymond Woodrow of Princeton University on Contract Relations with Federal Agencies. This committee has met many times for sessions lasting more than one day to work out the details of the engineering colleges' relationships with various agencies of the Federal Government. Many of these problems have been vexing and hard to resolve, but a point has been reached with a good many of the Federal agencies so they now wish to confer with this committee before making any changes in the usual contract procedures. Fortunately, the benefits of these discussions have accrued not only to members of the Engineering College Research Council but to all of those who hold similar contracts. This committee has concerned itself almost entirely with the programmatic type of research where colleges expect the Military or other Government agencies to cover the complete cost of such research. Every ECRC representative in each member institution has been informed of this committee's activities by receiving the minutes of all meetings and copies of all proposals made by representatives of Federal agencies. If by chance any institution has failed to receive this information, a check should be made directly with Mr. Woodrow to find out to whom such material has been mailed.

Many members of the Engineering College Research Council have served on the panels or committees of the Department of Defense's Research and Development Board. Many of these men have shared a feeling of frustration and have wondered if their services were being properly utilized and if proper cognizance was being taken of the results of the time and energy which they had spent in resolving scientific problems of considerable importance. It is with some feeling of loss that wo note the passing of the Research and Development Board and await with interest the results of the various pro-

posals to set up Assistant Secretaries for Research and Development in the Department of Defense. It is hoped that any Council on Research or any other body set up to advise on or to administer the Department of Defense's research program will be a truly effective body. The Engineering College Research Council offers its services in any capacity it can to make this program an effective one to increase the strength of this nation's defenses.

Much energy has been expended on the 1953 "Review of Current Research" in which the work of some 103 colleges is listed. Although an exact account has not been made, it is estimated that this represents some 8,000 research projects which, of course, vary widely in scope and which cover what appears to be the whole gamut of physical science. This Review, which now totals over 300 pages, contains an index listing some 7,000 separate topics giving a small idea of the scope of such research.

Year of Transition

The past year has been one of transition for the ECRC in that a new chairman was elected and a new secretary had to be found. This followed a period during which the former secretary was not able to assist in our work and during which we had to run on our previously attained momentum. We are now slowly getting going again.

The Council notes with sorrow and a feeling of personal loss the untimely passing of Professor A. A. Jakkula of the Texas A. & M. College who had served for the past two years as a member of the ECRC Executive Committee.

As Chairman of the Council, I would like personally to thank each and every member who has helped make this past year a success. The Secretary, the Executive Committee, and the members of all of our committees have worked hard. Many college representatives have made suggestions as to how we can be a more effective agent in expanding the Engineering College Research programs. We will welcome ideas from any sources on this constructive theme.

Respectfully submitted,

ERIC A. WALKER,
Chairman

Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.

Report for 1952-53 of the Vice President for Divisions and Committees

In his report last year my predecessor in office, Dr. L. E. Grinter, called attention to the increasing number of Instructional Divisions of the Society and to the importance of sustaining the vigor and fruitfulness of their activities. Specifically, he suggested the desirability of relating membership in the Instructional Divisions to the work of the comprehensive study that the Society had in prospect looking toward an evaluation of engineering education.

Under Dr. Grinter's able leadership the evaluation study has gone forward during the current year with members of the Instructional Divisions, organized into institutional committees, contributing helpfully to the progress of the undertaking. It is my belief that as the findings of the evaluation study are developed there will be yet greater opportunities for the Subject Matter Divisions to participate in this project by taking responsibility for delineating in greater detail some of the specialized aspects of curriculum proposals that may be suggested by Dr. Grinter's Committee. This will serve to extend in depth the activities of the Committee on Evaluation and help make the results of this comprehensive study increasingly useful to engineering colleges.

Several Divisions of the Society held semi-annual meetings during the past winter. The Division of Engineering Drawing met at the University of Nebraska, January 29 to 31, centering its program particularly around problems of manufacturing and design. A very successful workshop program was arranged by the Co-operative Engineering Division at Fenn College in Cleveland on January 22 and 23. The Division also worked earnestly throughout the year with the American Council on Education and with the Veterans Administration on special problems of Public Law 550 affecting students in co-operative colleges. Over three hundred representatives of industry and of engineering education met at Northwestern University on January 31 for the conferences sponsored by the Relations with Industry Division. Particular attention in this program was given to problems of engineering manpower and the recruitment of potential engineering students from the high schools.

Specialized Publications

A number of the Divisions of the Society have issued, from time to time during the year, specialized publications which have proved to be very helpful as supplements to the JOURNAL OF ENGINEERING EDUCATION. Among these are the *Civil Engineering Bulletin*, the *Journal of Engineering Drawing*, the *Machine Design Bulletin*, the *Heat Power News*, *Chemical Engineering Abstracts*, and the *Engineering Mechanics Division Bulletin*. These bulletins are financed by the Divisions, are ably edited, and contain many articles of timely interest and importance.

Under the leadership of Professor Ireson of Stanford University, the Industrial Engineering Division sponsored a summer school immediately preceding the Annual Meeting of the Society at the University of Florida. The theme of the summer school was "Quantitative Measures in Industrial Engineering Courses." The Seminar for Engineering Teachers, begun so auspiciously last year by the General Electric Company and the Society's Committee on Improvement of Teaching, has been continued this year sponsored jointly by the General Electric Company and the

Educational Methods Division of the Society. Dr. B. R. Teare again served as the Society's representative in the planning and conduct of this program which was held at Schenectady immediately preceding the Annual Meeting of ASEE. The Society is indebted to Vice President Boring for his initiative in conceiving this very serviceable program and for his good offices in obtaining financial support for it.

An innovation in the Annual Meeting Program for 1953 is the scheduling of a General Session given over to brief reports of important Society Committees for the purpose of familiarizing the membership with these activities and providing an opportunity for questions and discussion. Among the Committees reporting at this meeting are the Committee on Teaching Aids, which has prepared a bulletin listing teaching aids of special utility in various fields of engineering instruction, the Committee on Ethical Standards, and the Committee on Engineering Manpower. A panel discussion of the important work carried on during the year by the Committee on Evaluation of Engineering Education also forms part of this General Session.

Joint Meetings

The trend toward more joint meetings of Divisions and Committees has been continued at the Annual Meeting this year as a result of worth while experience with this type of program in the recent past. In general, too, a policy of fewer separate meetings and concentration of effort to get outstanding speakers has proved to be most satisfactory.

Mention should be made in this report of the fine work initiated during the year by two new Committees of the Society: the Committee on Recognition and Incentives for Engineering Education, and the Committee on Improvement of Society Functions.

One of the problems that always faces Committees and Divisions of the Society is that of finding a way to get together for the discussion of work that is being carried on. In an effort to provide an opportunity for round the table conferences of this kind, arrangements will be made for providing meeting rooms next fall at the Annual Meeting of ECPD, ECRC, and ECAC in New York at the Hotel Statler in mid-October. It is hoped that many of our Divisions and Committees will take advantage of this opportunity for discussion of common problems. Wednesday, October 14, has been suggested as the day when Committees of the Society might meet to best advantage without conflicting with meetings of the other organizations.

In concluding this report I am glad of the opportunity to express the sincere appreciation of Secretary Bronwell and myself for the very fine co-operation that has been given by chairmen and secretaries of Divisions and Committees of the Society. Their responsiveness to requests for information and the effectiveness with which they have planned their activities and the program for the Annual Meeting are highly commendable. It has been a great pleasure and privilege to work with them.

Respectfully submitted,

WILLIAM C. WHITE,
Vice President

Report for 1952-53 of Vice President in Charge of Sections and Branches

The major responsibility of the office of the Vice President in Charge of Sections and Branches for the year 1952–1953 has been concerned with the promotion of the "Paper Contest" for young engineering teachers, and with the problem of the unionization of engineers. These problems have been called to the attention of the Sections and Branches and they have all been active.

Invitations have been sent to the bordering Canadian Colleges to join those Sections of our Society adjacent to their physical locations and the aid of Colonel L. F. Grant, Chairman, Engineers' Council for Professional Development, has been solicited in furthering this project. Contacts with the Canadian colleges indicate that eventually they may wish to organize their own sections but as an interim move it has been suggested they join up with their United States associates.

Physical boundaries of the Missouri Section were changed to include the University of Arkansas, and it is now officially known as the Missouri-Arkansas Section.

Section activities have been at a high level throughout the country and many of the Section meetings have been attended by officers of the Society. I feel the Sections and Branches of the Society are in good order.

Respectfully submitted,

MAYNARD M. BORING,
Vice President

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Lamme Award

The Committee on Lamme Award is always anxious to get nominations for the Award from the membership of the Society. Any member may place a name in nomination; the selection will be made by the Committee by letter ballot.

The Lamme Award consists of a gold medal and bronze replica bestowed annually upon a distinguished engineering educator for excellence in teaching and contributions to the art of teaching; contributions to research and technical literature; achievements which contribute to the advancement of the profession; and engineering administration. The Lamme Trust Fund was established in memory of Benjamin Garver Lamme. For a brochure describing the Award and a nomination form, please write to the Secretary, Professor A. B. Bronwell, Northwestern University, Evanston, Illinois.

Nominations should be sent to the Chairman of the Committee, Dean F. E. Terman, College of Engineering, Stanford University, Stanford, California by February 1, 1954.

The George Westinghouse Award

The George Westinghouse Award is an annual award established in 1946 by the Westinghouse Educational Foundation to recognize and encourage outstanding achievement in the teaching of students of engineering. The Award consists of $1,000, together with an engraved certificate.

The Award has been established to encourage younger men who have shown by their past record, evidence of continuing activity as superior teachers. To them the Award may serve not only as a reward but as an incentive toward further achievement.

In order to achieve this intent, it is deemed essential to limit the Award to those who have not reached the age of 45 by the date of the annual presentation.

Nominations may be made by any person, organization, or group and are to be submitted before February 1, 1954 to the Chairman of the Committee on Award, Professor F. H. Pumphrey, University of Florida, Gainesville, Florida before February 1, 1954. Nominations must be made on forms available from either the Chairman of the Committee or from the Secretary of the Society. Nominations should be accompanied by significant evidence supporting statement and claims.

U. S. Army Scientific and Professional Personnel Program

The U. S. Army Scientific and Professional Personnel Program should be of special interest to recent engineering graduates who will shortly be inducted into the armed forces because it was designed to channel as many such persons as possible into Army billets which will insure the maximum utilization of their engineering or scientific training and experience for their own continued professional development and for the advancement of the Army's technical programs.

The program is described in detail in Department of the Army Special Regulation No. 615–25–11, dated 7 August 1952.

The regulations provide for the identification, classification, assignment, and utilization of those persons who are qualified to perform scientific and professional level duties in research and development, instruction and related work of professional or scientific nature.

Commanders of reception centers and other installations conducting initial reception processing are responsible for the proper identification and indoctrination of scientific and professional personnel and for their transfer to appropriate basic training.

Copies of the basic regulation are available from the Department of the Army, Washington 25, D. C.

The Engineering Manpower Commission of Engineers' Joint Council is very interested in the efficiency of the Scientific and Professional Personnel program. It feels that the dissemination of information regarding the existence of the program is vital to its success and would appreciate information regarding engineers and scientists qualified under the program who are not being utilized in their fields of special qualification.

Reprints Available . . .

Are you interested in receiving copies of the newly completed "Manual of Graduate Study" or the "Report of the Committee on the Improvement of Teaching"? Copies of these can be obtained from the Secretary's Office, the price of the Graduate Manual being 50¢ and that of the Report of the Committee on the Improvement of Teaching being 15¢ each or $8.00 per hundred. All orders should be accompanied by a check remittance.

Cooperative Research*

By FRANCIS M. DAWSON

Dean, College of Engineering

and

ALI BÜLENT ÇAMBEL

Assistant Professor of Mechanical Engineering, State University of Iowa

It is fortunate indeed that American industrialists realize the need for industrial research and promote it whenever feasible. Notwithstanding, there is evidence that the executives of our industrial family have not fully benefited from the potentialities of research. Many a company loses ground because it has no research department or because its existing research department is limited as far as personnel and physical facilities are concerned.

In this article an attempt will be made to explain how an industrial concern may enhance its research activities economically by asking capable engineering schools to assume the technical responsibility of necessary investigations.

Whether applied or fundamental, industrial research requires many things. Three of the most important are: 1) source material, 2) engineers and scientists, and 3) shops and laboratories.

Source material is needed because all research requires a knowledge of the previous investigations completed in the field. Much time and money may be conserved by knowing that a certain study is already completed and thus need not be repeated again. Schools of higher learning have excellent libraries in which may be found almost all of the technical books, journals and other communications. Furthermore, engineering professors frequently act as reviewers to learned magazines and to publishers and therefore are intimately familiar with some of the most recent developments in the technical field.

All industrial research requires the talents of engineers and scientists. Here again engineering schools may serve very satisfactorily because their faculties are composed of high caliber technical and scientific personnel. The teaching and research staffs of engineering schools include people who are trained in industrial applications as well as professors who have a good command of both theoretical and experimental research methods. These experts are trained and educated in diverse fields, and it would indeed be difficult for the average industrial company to gather together people with so many different experiences. Engineering teachers, being well versed in the fundamentals of science, may frequently undertake an investigation in a more economical way than might be suggested by a person who is not as familiar with the basic premises of a science.

In industrial research every theory must be proved experimentally and every design or new device must be tested for performance. This requires shops and laboratories. University and technology laboratories and shops are well equipped and may boast of equipment which is multifarious in scope and function.

So far the qualifications for industrial research have been discussed. It would be well to explain briefly how such work may be undertaken. Of course the details will vary depending upon the school initiating the study, the company assigning the problem and the problem itself.

Three Ways

Three ways of undertaking industrial research are: the awarding of contracts,

*Based on a discussion conducted during the "Industry and Education Conference" at the State University of Iowa, May 28, 1952.

the awarding of fellowships, or the employing of consultants.

In the contract plan a concern contracts that the school under consideration shall execute a certain investigation to determine specific phenomena. The college, in assuming the responsibility for the work, assigns members of its staff to carry out the solution of the problem in the best possible manner.

In the fellowship plan the problem to be investigated for the company is assigned to a graduate student as a thesis project. The fellowship recipient is an outstanding graduate engineer and works under the guidance of an experienced staff member who advises the student in his work.

Under the consultation plan an organization enters into a direct agreement with an engineering educator who is known to have a successful experience in the field of study.

The plan according to which a problem is to be investigated depends on the prevailing conditions. Some studies lend themselves better to fellowships while some may be effected more advantageously by contract. Irrespective of the plan chosen there are certain unwritten rules which may greatly improve the chances of a successful investigation and which may contribute towards a cordial company-school relation. These may be cited briefly as follows:

Rules for Successful Investigation

1) Any investigation, regardless of its form, should be arranged on the basis of a written agreement signed by the responsible authorities of both the school and the company. Oral agreements are not advisable and they often cause serious misunderstandings.

2) Both the sponsoring company and the contracting institution should each assign a qualified person to the project to maintain proper liaison and communication.

3) Periodic reports should be submitted by the school to the company. However, these should be scheduled so that the time of the research personnel is not monopolized by the preparation of the progress reports.

4) In general an investigation which is assigned to a school should be of a long term nature rather than an immediate need. Anything which must be solved in a very short time is not well suited to university type research unless it is very limited in scope.

5) The investigation should be undertaken as freely as possible. Any unnecessary restrictions guised under security or competition are not conducive to high caliber research.

6) In assuming the responsibility for an investigation the school should be certain that it is not competing with existing consulting firms or research institutes. This is especially true in the case of state or municipally supported schools. There are numerous investigations which consulting firms can not easily undertake and it is in this area that engineering schools may serve best.

7) In order that a school be a top institution, it is necessary that its faculty and students engage in research. It is only in rare instances that a person can be a great teacher without being a pioneer in his field of study. On the other hand students can mature into capable engineers only if they study in an atmosphere where technology is actively advanced. It should be remembered, however, that a school should never undertake research activities to the extent where its educational activities commence to suffer.

Conclusion

In conclusion it may be said that both schools and industry benefit from investigations initiated by mutual agreement. The challenges of industrial research oblige engineering schools to rise to new heights in science, technology and education. For industry, the results of academic research serve as an economical guide for better products and manufacturing techniques.

Report of the Treasurer

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEETS

Assets	June 30, 1952	June 30, 1953
General Fund:		
Cash—State Bank & Trust Co., Evanston	$29,627.76	$27,826.54
Petty Cash	300.00	300.00
U. S. Government Bonds Series G	30,700.00	30,700.00
Accounts receivable		
Advertising	2,747.44	3,588.01
Dues	1,800.00	1,800.00
Westinghouse Educ. Found.	323.69	474.01
Due from Lamme Fund		279.58
Income Cash in Hands of Lamme Trustee	133.86	
Prepaid Travel Expense	425.00	425.00
Inventory (nominal)	1.00	1.00
Furniture and Fixtures (Nominal)	1.00	1.00
	$66.059.75	$65,395.14
Life Membership Fund:		
Cash	209.95	212.06
U. S. Government Bonds Series G	1,000.00	1,000.00
Due from General Fund		25.00
	$ 1,209.95	$ 1,237.06
B. J. Lamme Fund:		
Cash	163.08	290.25
Income Cash in Hands of Trustee	—	237.25
Principal Cash in Hands of Trustee	9.00	3.86
Securities and Mortgages	5,132.73	10,137.87
	$ 5,304.81	$10,669.23
Liabilities and Capital		
Current Liabilities:		
Accounts Payable—Publications	—	—
Due to Life Membership Fund	—	25.00
Other Accruals	407.88	4,234.56
	$ 407.88	4,259.56
Dues Collected in Advance	508.25	864.21
Excess of Contributions over Disbursements		
Teaching Aids	6,975.12	6,228.11
Evaluation of Engrg. Educ.		187.30
	$ 7,483.37	$ 7,279.62

	June 30, 1952	June 30, 1953
Surplus:		
Reserve for Special Projects	$ 6,004.69	$ 5,317.19
Reserve for ECRC	6,056.62	4,253.16
Unappropriated Surplus	46,107.19	44,285.61
	$58,168.50	$53,855.96
	$66,059.75	$65,395.14
Life Membership Fund—Surplus	$ 1,209.95	$ 1,237.06
B. J. Lamme Fund:		
Due to General Fund	—	279.58
Surplus	5,304.81	10,389.65
	$ 5,304.81	$10,669.23

COMPARATIVE STATEMENT OF CHANGES IN SURPLUS AND SPECIAL ACCOUNTS

	12 Months Ended June 30, 1952	12 Months Ended June 30, 1953
General Fund—Unappropriated Surplus		
Balance at Beginning of Period	$41,838.71	$46,107.19
Add: Excess of Income over Expense	10,273.17	
Transfer to ECRC Reserve	(6,004.69)	
	$46,107.19	$46,107.19
Less: Excess of Expense over Income		3,491.18
Transfer from ECRC Reserve		(1,803.46)
Transfer of Income Cash to Lamme Fund		133.86
Balance at End of Period	$46,107.19	$44,285.61
Life Membership Fund		
Balance at Beginning of Period	$ 1,183.11	$ 1,209.95
Add: Contribution to the Fund	25.00	25.00
Interest on Fund	1.84	2.11
Balance at End of Period	$ 1,209.95	$ 1,237.06
B. J. Lamme Fund		
Balance at Beginning of Period	$ 5,372.19	$ 5,304.81
Add: Transfer of Income Cash for General Fund		133.86
Contribution Received		5,000.00
Earnings of the Fund	228.62*	230.56
	$ 5,600.81	$10,669.23
Less: Award and Expenses	296.00	279.58
	$ 5,304.81	$10,389.65

* Includes earnings of prior year $102.47.

COMPARATIVE STATEMENT OF CHANGES IN SPECIAL ACCOUNTS

	12 Months Ended June 30, 1952	12 Months Ended June 30, 1953
Receivable—Westinghouse Educational Foundation		
Balance at Beginning of the Period	$ 83.91	
Add: Expenses	399.69	
	$ 483.60	
Less: Reimbursement Received	159.91	—
Balance at End of Period	$ 323.69	
Teaching Aids Fund		
Balance at Beginning of Period	$ 4,362.50	$ 6,975.12
Add: Contributions Received	3,605.00	50.00
	$ 7,967.50	$ 7,025.12
Less: Disbursements	992.38	797.01
Balance at End of the Period	$ 6,975.12	$ 6,228.11
Evaluation of Engineering Education Fund		
Balance at Beginning of Period	—	—
Add: Contributions Received	—	$ 6,000.00
Less: Disbursements*	—	5,812.70
Balance at End of the Period		$ 187.30

* Includes $3,300 payment on contract for part-time secretarial services.

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	12 Months Ended June 30, 1952	12 Months Ended June 30, 1953	Budget 1953-54
Income:			
Current Dues—Individual	$39,719.28	$40,394.45	$40,600
Institutional	8,105.00	9,185.00	10,000
Sale of Publications	2,069.32	2,887.00	2,800
Advertising	10,896.21	13,390.97	18,500
Interest on Bonds	792.50	792.50	780
ECRC	3,560.86	247.08	
B. J. Lamme Fund	12.40		
Refund from EJC	407.71		
Refund of Unused Registration Fee of 1952 Meeting		689.24	
Miscellaneous		269.95	
Total Income	$65,563.28	$67,856.19	$72,680

	12 Months Ended June 30, 1952	12 Months Ended June 30, 1953	Budget 1953-54
Expense:			
Cost of Publications	$22,884.88	$26,062.46	$30,000
Administrative, Secretarial and Clerical Salaries	12,658.51	19,573.06	21,100
Retirement Emeritus	1,360.00	1,360.00	1,360
Travel—Secretary's Office	1,878.71	1,906.51	1,950
Postage, Telephone and Telegraph	1,565.83	2,364.13	2,400
Supplies and Sundry Printing	3,171.05	4,342.65	4,500
Dues—American Council on Education	100.00	200.00	200
Dues—EJC	—	204.00	550
Contribution—ECPD	500.00	500.00	500
Contribution—Life Membership Fund	25.00	25.00	25
Officers Travel	2,365.99	1,886.57	2,500
Meeting Expense	2,214.34	3,069.30	2,500
Expenses ECAC	1,126.99	1,301.37	2,200
Expenses ECRC	1,906.17	6,400.54	4,350
Committees and Conferences	658.22	926.16	1,300
Bonding, Auditor's and other Society Fees	296.59	359.84	
Special Projects and Miscellaneous			1,000
Purchase of Dictaphone	764.35		
Committee on Improvement of Teaching	815.64		
Purchase of Mimeograph	1,062.84		
Credit Received on IBM Typewriter	(65.00)		
Contribution to ECPD for Eval. of Engrg. Ed.		100.00	
Young Engrg. Teachers Award		300.00	
Graduate Manual		367.80	
Cooperative Engrg. Educ. Report		95.48	
Miscellaneous		2.50	
Total Expense	$55,290.11	$71,347.37	$76,435.00

COMPARATIVE STATEMENT OF INCOME AND EXPENSE

	12 Months Ended June 30, 1952	12 Months Ended June 30, 1953	Budget 1953-54
Total Expense	$55,290.11	$71,347.37	$76,435
Net Income (Net Loss) for the Period	10,273.17	(3,491.18)	
* Transfer from (to) ECRC Reserve	(6,004.69)	1,803.46	
Balance to General Fund Surplus	$ 4,268.48	($1,687.72)	($3,755)

Parenthesis indicates deficit.

* This transfer was authorized by the Executive Board June 25, 1952, in order to smooth the fluctuations in ECRC expense from year to year. The amount is calculated as the difference between expense and the sum of receipts and budgeted expenditures.

Minutes of Executive Board Meeting, Northwestern University, Evanston, Illinois, September 9–10, 1953

Meetings of the Executive Board of The American Society for Engineering Education were held at Northwestern University, Evanston, Illinois on September 9 and 10. Those present were: L. E. Grinter, *President*, W. L. Everitt, B. R. Teare, Jr., E. A. Walker, G. Farnham, A. B. Bronwell, C. E. Watson and M. Strohm.

Future Executive Board Meetings

The Executive Board discussed the schedule of Board meetings for the balance of the year. The next meeting will be held at the Engineers' Club, New York City on October 14 at 8:00 A.M. There will probably be a meeting in January, 1954 in New York City at the time of the AIEE Convention and, if necessary, a meeting in either March or April. The final meeting will be held at the time of the Annual Meeting in June.

The importance of having a member of the Executive Board present at Section meetings was discussed. Vice President Teare will write to Sections about arrangements for representation of the Executive Board at their meetings. The meetings west of the Mississippi involve considerable travel expense and do not fit into any kind of travel pattern. However, President Grinter will try to attend some of these.

Report of the Secretary

The Secretary reported on the plans for publication of the Report of the Committee on Financial Policy. The Board discussed means of informing the Society membership of the proposed plan for change in dues.

The Executive Board voted that a revision of the By-Law IV be prepared for submission to the General Council. If favorably adopted, this will be sent to the Society membership by letter ballot during the year.

The Executive Board voted that the dues should not be raised more than $1.00 in any given year.

The Secretary reported that appointments to the various Society committees have been nearly completed.

The Secretary will present a plan for hospitalization and Social Security for office staff to the Executive Board at the October meeting. At present the office secretaries have no hospitalization or Social Security benefits. Professors Bronwell and Watson are adequately covered by their affiliation with Northwestern University.

The Secretary reported that the Engineers' Joint Council is working with the National Science Foundation in the prepation of a roster of engineering personnel. This will consist of a finder list of 5000 people, distributed through all engineering occupations. In case of emergency, persons on this finder list will be consulted for personnel in their respective fields.

Report of the Treasurer

The Treasurer presented the final Annual Audit for 1952–53. This showed a deficit of $1688. This deficit was about $600 larger than anticipated in the preliminary audit. The Secretary explained that this occurred because the cost of printing Annual Meeting programs and the expenses of committees and conferences were both higher than had been anticipated when the preliminary audit was prepared. The Board voted to accept the Treasurer's Report.

Reports of Vice Presidents

Vice President Walker reported that sales of the *ECRC Review of Current Research* are going well. He felt that there ought to be advertising in the next issue of the *Review* to help cover publication costs and that the price should be raised. The *Review*

has been given excellent reviews in the technical press. Two copies were sent to all Institutional members. The Board suggested that copies of the *Review* be sent to members of the General Council.

Vice President Everitt reported that there will be an ECAC Executive Committee meeting on October 15 in New York City, at which time the Administrative Council will formulate its plans for the year. The August *ECAC Bulletin* contains information on ECAC operations and Committees. It was suggested that the *ECAC Bulletin* be sent to members of the General Council as one means of keeping them informed on Society functions.

Vice President Teare reported that he is preparing a letter which will be sent to ASEE Sections. He felt that there should be closer cooperation between Sections and Divisions in working on problems of mutual interest and in planning meetings. Dean Teare suggested that an effort be made to invite representatives of Associate Institutional members (company members) to attend Section meetings. Lists of Associate Institutional members will be sent to Section Chairmen. Vice President Teare reported that the Southeastern Section is planning to organize its Section along structural lines similar to those of the National organization, and that the Allegheny Section wishes to enlarge its Branch.

The Secretary reported that Vice President White had been in close touch with Officers of Divisions and Committees and had prepared an informative letter to go to all Division Chairmen.

ECPD Dues

The Executive Board reviewed a letter from the Engineers' Joint Council for Professional Development relating to an increase in contributions from constituent societies. In this proposal, the ASEE contribution would be increased from $500 per year to $700 per year. The Executive Board voted to request ECPD to establish a definite plan for levying contributions which would be adhered to in the future.

ASEE Sponsorship in Rapidly Developing Areas of Science and Technology.

The Executive Board considered the sponsorship of conferences of perhaps one or two weeks duration in the more rapidly advancing fields of sciences and technology. It was pointed out that the types of programs which ASEE sponsors at present allow very little depth of penetration. When curricular changes take place, they usually occur as a result of new advances in science and technology. It would seem therefore that a more thorough study of the newer fields of science and technology might be very helpful in appraising future trends in engineering education. It was suggested that the cooperation of industry be sought in financing the conferences and providing research engineers for programs.

This proposal has been submitted to the General Council. The Council recommended that a committee be appointed to study and implement the proposal. A meeting of the Chairmen and Council representatives of Divisions has been scheduled for October 14 to discuss this proposal.

Vice President Teare suggested that a tie-in of these conferences with Section Meetings be considered. He also suggested that a Section Meeting might be developed around such a conference.

The Executive Board requested that the Secretary prepare an editorial on the proposal for publication in an early issue of the JOURNAL.

The Executive Board voted that these conferences should have as their primary objective the study of research material in those areas which are likely to be translated into significant engineering practice in the years ahead, in order to clarify such material and reduce it to usable form for engineering teachers.

The Secretary read a letter from Dean Potter, suggesting that finances for such conferences might be obtained from the National Science Foundation.

Humanistic-Social Division Project

The Humanistic-Social Division has requested permission to initiate a project which will consist of a study of the Hammond Report to see what influence it has had on the courses in the social sciences and humanities in engineering education. The study would also investigate programs which seem to have unusual merit. It was proposed to solicit funds from the Ford Foundation to conduct this study.

The Executive Board signified general approval of the project, but requested that the proposal be revised in accordance with cer-

tain recommendations and be presented for approval at the October 14 meeting of the Board.

The Board voted to authorize the President, Vice President in Charge of Divisions, Secretary, and Professor Olmsted to discuss this proposal with officials of the Ford Foundation and the Carnegie Foundation.

Nomination of Officers

The desirability of electing at least one Officer of the ASEE from professional ranks was discussed. The Secretary reviewed the election procedure. Nomination forms are published in two issues of the JOURNAL and sent to Chairmen of all Divisions, Committees, and Sections. The Nominating Committee adds its nominations and then takes a noncommittal preliminary ballot sometime before the Annual Meeting. Final selection of the candidates is made by the assembled Committee at the Annual Meeting and is presented to the membership at a General Session for vote.

It was the opinion of the Board that this method of selecting Officers is better than that used by most societies. The desirability of having multiple candidates was discussed. It was pointed out that in cases where this method is used, there is a tendency to select candidates on the basis of their popularity, rather than performance, and also it would involve the Society in political battles which often place a stigma on the defeated candidates. The Nominating Committee as presently constituted consists of the retiring members of the General Council, who have been elected by the Divisions and Sections. It was the opinion of the Executive Board that there is probably no better group to select the candidates, since they have been working in the Society and are well-acquainted with the qualifications and performance of the leading individuals.

However, it was suggested that it would be appropriate for the Committee on Society Functions to write to the Chairman of the Nominating Committee and suggest that the Committee consider the advisability of selecting a candidate from professorial ranks.

Annual Meeting

Plans for the Annual Meeting were discussed. It was decided to withhold any action until the Committee on Annual Meeting has had an opportunity to formulate its proposals.

Requests for Summer Schools

The Humanistic-Social and Mechanical Engineering Divisions have requested permission to hold Summer Schools.

The Executive Board expressed favorable interest in the Summer Schools, but requested that a definite plan of subject matter be submitted by the Divisions and that action be taken at the October meeting of the Executive Board.

YET Paper Contest

The Executive Board moved to grant $300 in prize money for the YET Paper Contest this year, with prizes of $200, $100 and several Honorable Mentions as determined by the final judging committee.

The rules as adopted are published in this issue of the JOURNAL.

Report of Educational Methods Division

The Educational Methods Division submitted a report in the form of an analysis of articles appearing in the Journal of Engineering Education. This report expressed the opinion that there is room for more research papers dealing in a more penetrating manner with the problems of engineering education. In the discussion, it was pointed out that the articles published in the JOURNAL are limited largely by the material presented at meetings of the Society. Also it was suggested that the proposed conferences in technical areas will help to serve this function. Other projects of an educational research character were discussed by the Board.

The Executive Board voted appreciation of the report and expressed the opinion that this will be helpful in planning future ASEE meetings and activities.

Meeting of Physics Officers of AAPT and ASEE

The Board discussed the request of Dr. Seeger for funds for a meeting of the Physics committees of AAPT and ASEE. These committees are studying the problems of teaching modern physics in the engineering curricula as part of the project of Evaluation of Engineering Education. It

was pointed out that even by stringent use of the funds available, it did not appear that the Committee would have any more than enough to handle the probable expenses.

The Executive Board voted to grant $250, to be charged against Special Projects Funds for travel expenses to attend a joint meeting between the Physics Division of ASEE and AAPT.

Request of Dr. Armsby for Tavel Funds to Engineering Manpower Commission Meetings.

The Executive Board approved the request of Dr. H. H. Armsby for travel funds to attend meetings of the Engineering Manpower Commission as ASEE's representative, inasmuch as he has access to vital information needed by the Manpower Commission.

Request of AIEE for Joint Sponsorship of National Telemetering Conference

The AIEE has proposed a joint conference with ASEE on the subject of telemetering. The Board expressed the opinion that this subject is remote from engineering education and therefore decided not to authorize co-sponsorship.

Associate Institutional Memberships

The Executive Board voted to approve the following Associate Institutional Memberships:

Acme Steel
A. B. Dick Foundation
Allegheny Ludlum Steel Corp.
Armco Steel Corp.
Continental Oil Co.
Dictaphone Corp.
Friden Calculating Machine Co., Inc.
Inland Steel Co.
Minnesota Mining & Manufacturing Co.
Monsanto Chemical Co.
National Cash Register Co.
Ohio Oil Co.
Philadelphia Electric Co.
Pitney-Bowes, Inc.
The Pure Oil Co.
Republic Steel Corp.
Shell Development Co.
Youngstown Sheet and Tube Co.
North American Aviation, Inc.
Ford Motor Comany

The following Associate Institutional Memberships were approved by letter ballot to the Executive Board:

Armour and Company
Boeing Airplane Company
California Research Corporation
Consumers Power Company
Columbia-Southern Chemical Corp.
Columbia Broadcasting System-Hytron Division
Deere and Company
Florida Power Corporation.
General Radio Company
International Harvester
Lockheed Aircraft Corp.
Louisiana Power & Light Company
Lukens Steel Company
Sacony-Vacuum Labs.
Sprague Electric Company
The Toledo Edison Company
Wisconsin Power & Light Company

Breach of commitment by Air Force ROTC

A letter from Dean———to Vice President W. L. Everitt protesting that the Air Force by its reduction of ROTC quotas had committed a breach of faith with students was discussed. It was pointed out that this was necessitated by a reduction in Air Force appropriations. A year ago the ASEE protested the high ROTC quotas and any protest now would be a reversal of this position.

The Executive Board felt that this was a matter of considerable importance and recommended that the ECAC Military Affairs Committee consider the problem and decide if they should present a resolution for the October meeting. It was suggested that the Military Affairs Committee consider conducting a poll of engineering deans as to their opinion on the desirability of protesting the precipitous action of the Air Force ROTC to determine:

1. Do you feel that a moral commitment to the student has been broken by the method of the recent reduction of the Air Force ROTC?

2. Do you desire ASEE to make a protest in the name of the engineering colleges?

Reply should be received by October 14.

Representation at NCSBEE Meeting

Dean W. R. Woolrich was appointed to represent ASEE at the meeting of the National Council of State Board of Engineering Examiners at San Antonio.

Respectfully submitted,

A. B. BRONWELL,
Secretary

Chairmen of ASEE Sections, 1953–54

ALLEGHENY: W. I. Short, University of Pittsburgh
ILLINOIS-INDIANA: R. G. Owens, Illinois Institute of Technology
KANSAS-NEBRASKA: M. H. Bernard, University of Nebraska
MICHIGAN: F. L. Schwartz, University of Michigan
MIDDLE ATLANTIC: C. Bonilla, Columbia University
MISSOURI-ARKANSAS: V. J. Blum, St. Louis University
NATIONAL CAPITAL: C. H. Walther, George Washington University
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ROCKY MOUNTAIN: A. Diefendorf, University of Utah
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Chairmen of ASEE Committees, 1953–54

ANNUAL MEETING: W. C. White, Northeastern University

ASSOCIATE INSTITUTIONAL MEMBERSHIP: J. C. McKeon, Westinghouse Electric Corp.

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ENGINEERING SCHOOL LIBRARIES: Johanna Allerding, University of California

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PRINTING ECONOMY (Ad Hoc): G. W. Farnham, The Ronald Press Company

PROMOTION OF ETHICAL STANDARDS: C. J. Freund, University of Detroit

PUBLICATIONS: A. B. Bronwell, Northwestern University

PUBLIC RELATIONS: L. A. Rose, University of Illinois

RECOGNITIONS AND INCENTIVES FOR GOOD TEACHING: R. W. Schmelzer, Rensselaer Polytechnic Institute

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SOCIETY FUNCTIONS: B. R. Teare, Jr., Carnegie Institute of Technology

TEACHING AIDS: Editorial Committee on Teaching Aids Bulletin—F. D. Carvin, Illinois Institute of Technology

TEXTILE ENGINEERING: C. L. Adams, Alabama Polytechnic Institute

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In Memoriam — Alfred Holmes White

Engineering educators all over the country were saddened by the sudden death of Professor A. H. White, former President of the American Society for Engineering Education, in August. Alfred Holmes White, educator and chemical engineer, was born April 29, 1873 in Peoria, Illinois, where he received his early educational training before going on to McGill University for a year. In 1893 he received an A.B. degree with specialization in chemistry from the University of Michigan and in 1904 received his B.S. degree from the same school. In the meantime, he had studied at the Federal Polytechnic School in Zurich, Switzerland in 1896–97 while on leave from the faculty of the University of Illinois.

He joined the University of Michigan faculty as Instructor in Chemical Technology in 1897 and moved successively through academic ranks until he became Head of the Department of Chemical Engineering in 1914 when Edward de Mille Campbell asked to be relieved of the duties. He continued as Chairman until 1942 and became Professor Emeritus of Chemical Engineering in 1943.

Professor White's fundamental work on portland cement, gas and fuel analysis was well-known before World War I. During the war he served in the Ordnance Department and acted as technical director of the Nitrate Division, returning to the University with the rank of Lieutenant Colonel.

Since that time, the department he headed has grown to front rank, with increasing curricula and graduate work. He was one of the most active supporters and had great influence on policy and progress of the Engineering Research Institute at the University, then known as the Department of Engineering Research, organized in 1921 as the contracting agency for sponsored research in engineering and the physical sciences.

Professor White's life-long interest in general education as well as his chosen field of chemical engineering culminated in his Presidency of the Society for the Promotion of Engineering Education (the present American Society for Engineering Education) in 1941–42, a difficult year when war demands were upsetting education, particularly engineering education.

His professional interests are also reflected in his activities in the American Institute of Chemical Engineers where he served as Director, Vice President and President.

His publications include the books "Technical Gas and Fuel Analysis" and "Engineering Materials," the latter a basic engineering text widely used in colleges, some seventy research papers on gas and fuel, hydraulic cements, nitrogen fixation, boiler waters, twenty-eight general papers and thirteen patents.

Education in general and engineering education in particular has lost a most valued and understanding protagonist whose broad perspective in his field is best evaluated when it is realized that his career began with the infancy of chemical engineering as a profession and paralleled the field's growth to its immensely important position today in education, industry and the military.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh		W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	University of Pennsylvania	Dec. 5, 1953	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Library of Congress	Feb. 2, 1954	C. H. Walther, George Washington University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

BADGER, PARKER HOLMES, Instructor Heating, Refrigeration and Air Conditioning, Milwaukee School of Engineering, Milwaukee, Wisconsin. F. Kaufman, H. M. Werwath.

BALABANIAN, NORMAN, Instructor Electrical Engineering, Syracuse Univ., Syracuse, New York. A. B. Bronwell, L. E. Grinter.

BARNEY, WM. GEORGE, Assistant Professor Mechanical Engineering, University of North Dakota, Grand Forks, North Dakota. E. C. Lawson, P. J. Reiten.

BENDER, MILTON EDWIN, JR., Assistant Professor Civil Engineering, Colorado A & M College, Fort Collins, Colorado. T. H. Evans, J. E. Cermak.

BERGGREN, WILLARD PAUL, Director, Engineering Division, University of Bridgeport, Connecticut. W. R. Chambers, R. C. Robertson.

BIERLY, GEORGE W., Assistant Professor Engineering, Penna. State College Ext., Wilkes-Barre, Penna. K. L. Holderman, V. E. Neilly.

BIGGS, ALFRED C., Instructor Mechanical Engineering, Washington State College, Pullman, Washington. H. A. Sorensen, H. J. Dana.

BREAZEALE, WILLIAM M., Professor Electrical Engineering, Penna. State College, State College, Penna. E. A. Walker, E. B. Stavely.

BROWN, WENTWORTH KIMBALL, Assistant Professor English, Rensselaer Polytechnic Inst., Troy, New York. D. H. Washburn, S. P. Olmsted.

BURT, FREDERICK CHARLES, Instructor English, Newark College of Engrg., Newark, New Jersey. F. A. Grammer, P. M. Giesy.

CARMICHAEL, WILLIAM LAWSON, Registra., Georgia Inst. of Technology, Atlanta, Georgia. P. Weber, H. S. Weber.

CARSON, ROBERT GORDON, JR., Associate Professor, Textile Management, Clemson Agricultural College, Clemson, South Carolina. R. A. Banister, D. D. Curtis.

CATTANEO, LOUIS E., Assistant Professor Civil Engineering, Catholic University of America, Hyattsville, Maryland. H. P. Gallogly, F. Biberstein.

CENKO, STEPHEN, Instructor Product Service, General Motors Institute, Flint, Michigan. C. A. Brown, M. L. Gilbert.

CHRISTIANS, GLENN ARTHUR, Director of Admissions, Milwaukee School of Engineering, Milwaukee, Wisconsin. F. Kaufman, C. O. Werwath.

CHRISTOPHER, PHOEBUS M., Assistant Instructor Chemistry, Newark College of Engineering, Newark, New Jersey. M. Branin, J. H. Beiley.

CLARK, LEWIS DONOVAN, Acting Head Mining and Metals Dept.; Associate Professor of Mining Engineering, Lafayette College, Easton, Pennsylvania. L. J. Conover, W. S. Lohr.

CLEAVER, MAURICE, Personnel Supervisor General Personnel Dept., Southwestern Bell Telephone Company, St. Louis 1, Missouri. D. S. Bridgman, R. A. Deller.

CONNELLY, DOUGLAS MELVILLE, Instructor Architecture and Engineering, West Contra Costa Junior College, Richmond, California. W. J. Luzadder, A. S. Levens.

CROSS, THOMAS, JR., Coordinator Tech. Employment, Standard Oil Development Company, Linden, New Jersey. E. E. Elsey, J. S. Horine.

DANGELMAYER, WYNTON R., General Employment Manager—Personnel, New England Telephone and Telegraph Co., Boston, Massachusetts. W. E. Keith, C. E. Tucker.

DOMINGUE, EMERY, Assistant Professor Civil Engineering, Southwestern Louisiana Institute, Lafayette, Louisiana. F. Harding, H. M. Morris.

DOWNES, JOHN ROGER, Assistant to President, Milwaukee School of Engineering, Milwaukee, Wisconsin. F. Kaufmann, C. O. Werwath.

DULTZIN, SAMUEL D., General Manager, Equipos Industriales, South America; Mailing address: Lebnitz 161, Mexico 5 D.F. Mexico. Ahuza, V. B.

DUNLAP, A. LEE, Professor Mechanical Engineering, Tulane University, New Orleans, Louisiana. A. M. Hill, L. H. Johnson.

FISH, WALTER A., Director Technical Recruiting, Merrimac Division, Monsanto Chemical Company, Everett Station, Boston 49, Massachusetts. R. F. McCoole, P. N. Powers.

FISHER, JAMES HAYDEN, Assistant Professor Electrical Engineering, University of

Washington, Seattle 5, Washington. A. V. Eastman, F. R. Bergseth.

FOBER, FREDERICK CARL, Technical Instructor, Ford Motor Company, A.E.D., Chicago, Illinois. E. F. Kosner, H. H. Katz.

FRANCK, CLARENCE C., Manager Land Turbine Engineerisg, Steam Division, Westinghouse Electric Corp., Lester P.O., Philadelphia 13, Pennsylvania. S. C. Hollister, F. M. Dawson.

GARRETT, EVERETTE T., Assistant Professor Electrical Engineering, USAF Institute of Technology, Wright-Patterson Air Force Base, Ohio. L. F. Lewis, W. J. Price.

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GROVES, MARION HERBERT, Assistant Dean Graduate School, Illinois Institute of Technology, Chicago 16, Illinois. W. A. Lewis, C. A. Arents.

GULDBERG, OVE, Managing Director of The Institution of Danish Civil Engineers, Copenhagen V. Denmark. W. R. Woolrich, A. B. Bronwell.

HALLER, MARY ELIZABETH, Associate Professor of Mathematics, University of Washington, Seattle, Washington. E. R. Wilcox, A. B. Bronwell.

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HOISINGTON, ROBERT H., Assistant Professor Engineering Drawing, University of Michigan, Ann Arbor, Michigan. F. Smith, R. Heppinstall.

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KADUSHIN, JACK, Supervisor Engineering Training, Lockheed Aircraft Corp., Los Angeles 36, California. R. R. O'Neill, J. C. Dillon.

KEICHER, PAUL EDWARD, Instructor Engineering Drawing, Syracuse University, Syracuse, New York. A. B. Bronwell, L. E. Grinter.

KLEVICKIS, ALGERD C., Coordinator of Training, Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota. P. A. Cartwright, G. J. Murphy.

KOONS, PAUL CLIFTON, JR., Acting Director Research Assoc., Engr. Exp. Station, Louisiana State University, Baton Rouge, Louisiana. L. J. Lassalle, H. Flanakin.

KREITH, FRANK, Acting Assistant Professor Mechanical Engineering, University of California, Berkeley, California. E. D. Howe, P. B. Stewart.

KRELLWITZ, WM. GEORGE, General Personnel Relations Supervisor, Wisconsin Telephone Company, Milwaukee, Wisconsin. A. B. Drought, R. J. Panlener.

KRICK, EDWARD VANORDER, Instructor, Mechanical Engineering, Cornell University, Ithaca, New York. R. F. Chipak, M. W. Sampson.

LANHAM, FRANK BRISTOL, Secretary, American Society of Agricultural Engineers, 505 Pleasants St., St. Joseph, Michigan. F. R. Jones, P. Hobgood.

LEVITT, JOSEPH R., Associate Professor Mechanical Engineering, University of Bridgeport, Bridgeport, Connecticut. R. W. Petrie, M. S. Ojalvo.

LITTLEJOHN, CHARLES EDWARD, Associate Professor Chemical Engineering, Clemson College, Clemson, South Carolina. H. E. Glenn, J. H. Sams.

LORING, DOUGLAS WINTHROP, Assistant Vice President, Southern New England Telephone Co., New Haven 6, Connecticut. A. B. Bronwell, L. E. Grinter.

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LOUX, MAYNARD ZIEGLER, Associate Professor Management Engineering, Rensselaer Polytechnic Institute, Troy, New York. A. A. K. Booth, K. H. Moore.

MCGARRY, FREDERICK JEROME, Instructor, Dept. of Bldg. Engrg. and Construction, Massachusetts Institute of Technology, Cambridge, Massachusetts. W. C. Voss, A. G. H. Dietz.

MCHOSE, ANDRE H., Research Associate, Engineering Research, Penn. State College, State College, Pennsylvania. V. E. Neilly, R. E. McCord.

MERRILL, EDWARD WILSON, Assistant Professor, Chemical Engineering, Massachusetts Institute of Technology, Cambridge,

Massachusetts. W. K. Lewis, E. L. Cochrane.

MIDDLEWOOD, ROBERT W., Chief Engineer, Lockheed Aircraft Corp., Georgia Division, Marietta, Georgia. F. W. Ajax, D. W. Dutton.

MOORE, CHESTER ARTHUR, Professor and Head Civil Engineering Dept., University of Idaho, Moscow, Idaho. H. E. Hattrup, N. F. Hindle.

NEALE, LAWRENCE CARLTON, Instructor Mechanical Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts. L. J. Hoyer, J. S. Marcus.

O'BYRNE, JOSEPH MICHAEL, Assistant Professor Mechanical Engineering, University of Florida, Gainesville, Florida. T. O. Neff, E. H. Lewis.

OPHUS, JAMES CAREY, Associate Professor Engineering, University of Portland, Portland, Oregon. G. H. Bliesner, W. Brenton.

OTTOSON, GERALD EDWIN, Tech. and Admin. Personnel, Solvay Process Divn, Allied Chemical & Ore Corp., Solvay, New York. A. B. Bronwell, L. E. Grinter.

RAGAN, PHILIP HISEY, Manager, Manufacturing Educational Service, General Electric Company, Schenectady, New York. F. Lewis, M. M. Boring.

RAZOR, CHARLES THURSTON, Head Electrical Engineering, The Citadel, The Military College of South Carolina, Charleston, South Carolina. J. Anderson, J. C. Key.

REINHARD, PAUL M., Assistant Professor Engineering, University of Detroit, Detroit, Michigan. W. Felbarth, S. Osborne.

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SCOTT, RAYMOND C., Assistant Professor Engineering Drawing, University of Michigan, Ann Arbor, Michigan. P. O. Potts, H. W. Miller.

SIGNER, M. I., Dean of the Faculty, Colorado School of Mines, Golden, Colorado. G. W. LeMaire, R. A. Baxter.

SIMPSON, THOMAS RUSSEL, Professor of Irrigation Engineering; Engineering, University of California, Berkeley, California. H. B. Botaas, E. D. Howe.

SLEGEL, LOUIS, Professor Mechanical Engineering, Oregon State College, Corvallis, Oregon. C. O. Heath, Jr., R. A. Wanless.

SWANSON, RICHARD EUGENE, Assistant Training Director, Personnel, Minneapolis-Honeywell Regulator Co., Minneapolis, Minnesota. P. A. Cartwright, G. J. Murphy.

SWINTON, ROY STANLEY, Professor Engineering Mechanics, University of Michigan, Ann Arbor, Michigan. A. B. Bronwell, L. E. Grinter.

TERRY, THEODORE A., Instructor Mechanical Engineering, Lehigh University, Bethlehem, Pennsylvania. J. B. Hartman, D. M. Parke.

VALLESE, LUCIO MARIO, Assistant Professor Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, New York. E. Weber, F. A. Wahlers.

VINES, QUENTIN C., Associate Professor Industrial Engineering, University of Michigan, Ann Arbor, Michigan. A. B. Bronwell, L. E. Grinter.

WADLIN, GEORGE KNOWLTON, JR., Assistant Professor of Civil Engineering, University of Maine, Orono, Maine.

WALLSCHAEGER, THEODORE W., Principal, John Palmer School, Chicago, Illinois. H. Reingold, S. E. Winston.

WATSON, RALPH M., Director of Research, Worthington Corp., Harrison, New Jersey. R. S. Sherwood, A. B. Bronwell.

WIREN, ROBERT CHARLES, Professor Mechanical Engineering, University of Toronto, Toronto, Ontario, Canada. W. G. McIntosh, I. W. Smith.

WILSON, ALBERT ROBERTS, Manager, Technical Recruiting, Monsanto Chemical Company, LaMarque, Texas. R. F. McCoole, N. F. Rode.

YOUNG, HEWITT HARTLEY, Assistant Professor Industrial Engineering; General Engineering, Purdue University, Lafayette, Indiana. O. S. Hulley, H. T. Amrine.

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84 New Members elected this year

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Do You Know—

► The Fall Meeting of the ASEE and ECPD in New York was an outstanding success. The program on "Creative Thinking," sponsored by ECRC and ECAC, dealt with an intriguing subject which certainly needs further exploration. It was highly stimulating to hear the musician, the artist, and the writer discuss the creative thought processes in their respective fields. This is a promising field of development and one which our ASEE groups might well explore for program material. It emphasizes the values to be gained by developing interdisciplinary conferences between the various learned fields.

The Fall Meeting also featured discussions on accreditation of the engineering curricula. There seems to be a unanimity of opinion that the minimum standards of accreditation should be raised in order to achieve an overall improvement in engineering education. The controversial subject dealt with the desirability of special designation for engineering curricula which are particularly meritorious. There seems to be considerable divergence of opinion on this proposal and it is one which certainly deserves very careful study before decisions are made.

If you are wondering why you did not receive an announcement of the Fall Meeting, these announcements were mailed only to the Officers of ASEE Divisions, Committees, Sections and members of the General Council. The complete program was published in the September Issue of the Journal. The Fall Meeting is an outgrowth of closed conferences which were formerly held by the ECRC and ECAC for their Institutional Representatives. The meeting this year served as an excellent opportunity for those who are responsible for planning the activities of ASEE for the coming year to get their planning committees together.

► The Committee on Evaluation of Engineering Education has prepared a preliminary report which was distributed to the Institutional Committees in engineering colleges cooperating with the Committee. Dan Pletta has done an excellent job in preparing this report and it is hoped that the cooperating institutions will study this report carefully and prepare their own comments and recommendations.

You will want to study the proposals of the Committee on Evaluation of Engineering Education summarized on page 169 of this issue of the JOURNAL. This is a condensation of three subcommittee reports which have been sent to the Institutional Committees for criticism. If you have any suggestions, please send them to the Secretary of the Committee, Professor Pletta.

► Tentative plans have been made by the following Divisions to hold Summer Schools either before or immediately after the Annual Meeting at the University of Illinois: Humanistic-Social Division, Mechanical Engineering Division, Mechanics Division, Engineering Economy Committee, Electrical Engineering Division. In addition to these, there is planned a joint meeting of the Instrument Society of America and ASEE, to be held on Saturday, June 12, immediately preceding the Annual Meeting.

This year the General Electric Company will again repeat its Summer School for a select group of young engineering teachers. The Summer School will be held at Schenectady and will feature some

of the instructional methods used in the advanced engineering course at the General Electric Company. This Summer School is co-sponsored by the Educational Methods Division of ASEE.

► The proposal to conduct Summer Institutes was considered by representatives of Divisions and members of the General Council at the time of the Fall Meeting in New York. Two Summer Institute conferences are being planned for the summer of 1954. One of these conferences will explore the subject matter in the area of Solid State Physics; the other will deal with Nuclear Science and Engineering. The objective of these Summer Institutes is to explore some of the newer areas of science and technology in order to obtain an orderly and systematic organization of fundamental concepts as well as to evaluate this material for teaching purposes in the engineering curricula. The tentative plan is to hold a closed conference of from about ten to twenty "experts" in research and teaching for a three to five day period in the Spring of 1954. This conference will lay the groundwork for an open conference to be held during the Summer of 1954. Tentative plans for the Solid State Physics conferences are to hold a closed conference at the University of Illinois and an open conference at Carnegie Institute. For the Nuclear Energy Conference, it is proposed to hold a closed conference at Columbia University and an open conference at Northwestern University. More specific details will be given later.

► The plans for the Annual Meeting are shaping up well. They indicate vigorous activity and promising new fields of development. One feature which is being planned is a joint conference of the Physics Divisions with several of the curricular Divisions of ASEE to thrash out the subject of the teaching of Physics in the engineering curricula. This would include a discussion of the desirability of incorporating in the engineering curricula some of the fundamental concepts in the newer areas of physics, such as nuclear physics, atomic physics and solid state physics. It will also include a discussion of the possibility of achieving integration of subject matter in the physics and engineering courses at the sophomore level.

► An exceedingly promising development is that a number of engineering colleges have now formed their own local YET organizations for young engineering teachers. Young engineering teachers can gain a great deal in depth and breadth of understanding of the engineering profession and engineering teaching by participating in activities of this kind.

Again, let us remind the young engineering teachers of the YET Paper Contest. The rules are published in this issue of the JOURNAL OF ENGINEERING EDUCATION. All entries must be submitted to the ASEE Section Chairmen not later than March 1. Here is an opportunity to gain national distinction. Good luck!

► The ASEE has a number of hot irons in the fire. Watch this column in the months ahead and we will try to keep you informed of the progress. Regards.

ARTHUR BRONWELL,
Secretary

Relation of Membership Dues to the Financial Problems of ASEE

By L. E. GRINTER, *President ASEE*

Your Committee on Society Finances consisting of three past presidents has given careful consideration to the financial stability of ASEE and has made its recommendation for an increase in the dues of all members in its report in the September JOURNAL. I wish to give you my reaction to this report since I consider the raise in dues of any society to be a matter of proper concern to officers and members alike.

The dues of ASEE have been raised from $5.00 to an average of $6.25 in the past twenty years. This is an increase of 25 per cent during a period when even the salaries of teachers have doubled. The Society could not have survived on such low dues if its membership had not been growing. Every administration knows that it is easy to balance an expanding budget, and, as the chart on the Society income published in the September JOURNAL shows, ASEE income has increased from $15,000 a year in 1935 to over $60,000 for 1953. This increase in income is due to a large increase in membership and also to increased advertizing income in the JOURNAL.

Despite the large growth in Society income the cost of serving our expanded membership has gone up so rapidly that a deficit of $1700 occurred during the past year and the budget adopted by the Council anticipates a deficit of $4000 for the current year. This cannot continue or the Society will become bankrupt.

Since I served as a vice-president from 1950 until 1952, I have had to study three or four annual budgets of the Society rather carefully. Our operations are really fantastically economical. We pay no headquarters rental and have almost no physical property. Our Secretary is a part-time professor and his assistant is a full-time professor who devotes only 18 hours a week to our publication work. There are only three full-time employees who are our office secretaries. The total salary cost is less than 50 per cent of that considered normal for societies of comparable size. We badly need another girl in the office for general clerical work, but the Executive Board is unwilling to increase the deficit that we must inevitably suffer this year.

Our expenses besides salaries include $30,000 for publishing the JOURNAL, which is 40 per cent of our income. We are looking into the possibility of reducing this large expense item but the committee that I have appointed to make this study, which includes publisher representatives, is not optimistic that a major saving will be possible. Our other costs include postage, telephone, printed announcements, annual meeting expense, bonding and auditors fee and such dues as the ASEE must pay to ECPD, EJC and American Council on Education. These are essentially fixed costs. The budget includes $2200 for the expenses of ECAC and $4350 for ECRC publications which is largely returned through the sale of the publications. Travel amounts to $4550 which could be reduced. However, it has been the opinion of all Executive Boards on which I have sat that the influence of Engineering Education should be brought to bear upon Engineers Joint Council and other national bodies of a similar

nature by having ASEE represented in as many such discussions as possible.

My analysis of the financial operations of ASEE has led me to the following conclusions:

(1) The Society should continue the association of its national headquarters with a University where space will be available either at no cost or at nominal cost.

(2) A part-time Secretary of professional status is a workable long-term arrangement if adequate secretarial and clerical service is provided. The present salary budget even when increased by one additional clerical worker is desirably low.

(3) Engineering Education requires a monthly publication. Whatever net cost above advertizing income that is involved must be borne by dues income.

(4) All other expenses in the present budget including travel are extremely modest for a society of national standing. In order for Engineering Education to have a sufficient impact upon national professional engineering decisions, a gradual increase in these expenses must be anticipated.

(5) In a small society it is very dangerous to be involved with a fixed income that offers no possibility of expansion to meet inflation or necessary changing expenses. An appropriate body, preferably the General Council, should have authority to adjust dues annually to meet the budget that it considers necessary. It is wise, however, to set an upper limit upon dues, which limit can only be raised by a written ballot of the membership.

The Ballot on Dues. At its meeting on October 15, 1953 the General Council of ASEE decided that a mail ballot should be prepared which, if voted, would make the General Council responsible for setting the dues to provide a balanced budget. The Council recommends that upper limits or ceilings be established of $7.00 for members under 36 years of age and $10.00 for other members. It is proposed that the dues for the first year after approval of the increase by the Society membership be $6.00 for members under 36 years of age and $8.00 for others. The proposal will also specify that the dues should not be increased by more than $1.00 per year after the first year.

I believe that this ballot should be approved by the membership of ASEE. It provides our Society with financial stability for the foreseeable future. It gives to the General Council the full responsibility for maintaining a balanced budget, yet it protects our membership in two ways: first by establishing a ceiling on dues, and second by restricting the dues increase for any member in any year. The proposed By Law represents both justice and wisdom.

Summary of Preliminary Report Committee on Evaluation of Engineering Education

H. H. Armsby
M. M. Boring
G. G. Brown
A. B. Bronwell
R. S. Burington
J. F. Calvert
A. P. Colburn
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F. C. Lindvall
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G. Murphy
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T. Saville
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R. L. Sweigert
K. F. Tupper
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E. Weber
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C. L. Wilson
W. R. Woolrich
D. Young

Co-Chairmen for the Four Sub-Committees

L. M. K. Boelter
W. L. Everitt
S. C. Hollister
B. R. Teare
L. E. Grinter, *Chairman*
D. H. Pletta, *Secretary*

The Committee on Evaluation of Engineering Education was appointed in May, 1952 by Dean S. C. Hollister, then President of the American Society for Engineering Eucation. The charge to the Committee was to determine the pattern or patterns that engineering education should take to provide the leadership that the profession must have 25 years from now. It had become evident that the tremendous strides taken in the physical sciences during the past decade had begun to influence requirements being placed upon the profession of engineering while only minor adjustments have occurred in engineering education.

As examples of the increased importance of the basic sciences in engineering progress one can point out that electronic developments have demanded greater knowledge of physics from electrical engineers. Such problems as continuity between structural members produced by welding and problems of vibrations of suspension bridges have demonstrated the need for greater scientific background for civil engineers. Mechanical engineers found new fields for research in heat transfer, fluid mechanics and later in jet and rocket propulsion. Practical metallurgy has changed from an art to a science based upon physical chemistry and physics of the solid state. The need for newer reactor materials, new nuclear-thermal processes and new materials and systems for radiation protection add to our picture of the increasing influence of science upon engineering practice. Hence, even without considering the major changes that are inevitable in engineering as nuclear power becomes available, we conclude that the many developments of the past ten or fifteen years would inevitably necessitate major changes in the character of engineering education.

From another direction there comes an even greater influence upon education in engineering. Since 1940 a large percentage of research physicists have had their interests reoriented toward nuclear problems, and it seems doubtful if the interest will ever be returned in sufficient meas-

ure to influence greatly the research in vibrations, elasticity, plasticity, heat transfer, engineering thermodynamics, fluid flow, and the other engineering sciences. Hence, engineers have become responsible for the continuity of research in all the fields of engineering science. The leaders of the engineering profession 25 years hence must be engineers who are at no loss in interpreting or themselves contributing to the extension of the fields of engineering science. Typical curricula of the era 1910–1940 were not designed with such an objective in mind.

Curricula Considerations

Basic Science. The basic sciences for all engineering curricula include mathematics, physics and chemistry. Mathematics through ordinary differential equations seems close to a minimum essential for all engineers. Chemistry deserves increased emphasis in engineering education and for a larger proportion of engineers considerably more than the usual freshman chemistry course is necessary. The Committee has on three occasions indicated its belief that modern physics including nuclear and solid-state physics has become an essential study in engineering. Since the physicists' teaching of mechanics, thermodynamics and electricity is at least partly duplicated in engineering courses, it is believed that better coordination would provide opportunity for the study of modern physics. The Committee, therefore recommends greater emphasis upon basic science in engineering curricula.

Engineering Sciences. The Committee has recognized nine important background sciences in engineering: They are statics; dynamics; strength of materials; fluid flow; thermodynamics; electrical circuits, fields and electronics; heat transfer; engineering materials; and physical metallurgy. It is believed that all of these studies should be represented in curricula that train engineers for service in research, development or design and that probably seven should be integrated into every curriculum that is represented as education for engineers.

Analysis, Design and Engineering Systems. Such studies of the junior and senior years, along with the necessary background of the engineering sciences, represents the features that distinguish engineering education from education in science on the one hand or technical institute education on the other. In all curricula except those intended for training in management or other general professional service, studies in design, or in analysis leading to design, should occur as an integrated study over four successive semesters. Even the most general curricula should include such studies as a continuing program for at least two semesters.

Non-Departmental Engineering Courses. Curricula often contain certain engineering courses selected for broadening purposes such as electrical engineering for non-electricals and heat engines for non-mechanicals. When given, such courses should limit the study of special machines or devices including their construction, production or operation. The Committee affirms its conviction that the most important broadening courses in engineering are those listed as the engineering sciences.

Humanistic-Social Studies. The Committee recognizes the importance of social studies and the humanities as an important part of an engineer's education. Such studies reveal the richness of human experience so that students may in turn enrich their own lives. They should trace the political, economic and social history of mankind to give students a clearer perspective of our civilization today. They should provide inspiration for seeking greater knowledge and understanding They should aid the student to develop judgment and discrimination, a sense of value, and a sound personal philosophy.

The seeking for immediate usefulness in the social studies and humanities, as tool subjects in engineering, may well lead to failure to achieve the objectives set forth

above. Such courses as accounting, industrial psychology, investment economics comparative costs, or city management may be just as technical as engineering studies. It is outside of such fields that the social-humanistic studies must lead the student. The Committee recommends a much broader study of the effectiveness of the social-humanistic stem of engineering education.

Faculty Selection and Development

Since a more scientific approach to engineering education is needed it will be essential to improve the scientific background of engineering faculties. Within a given faculty there should exist a balance of experience in both the science and art of engineering. An educational background which includes the Ph.D. degree is the strongest evidence usually available to measure the probable usefulness in teaching and research of a relatively young candidate for a faculty position. For older persons evidence of the productivity of the individual in creative teaching and research may be gaged by other criteria, and the formal educational background is of less significance.

Engineering education cannot develop superior students without developing superior teachers who will be recognized as creative leaders in the fields in which they teach. A faculty that can be expected to provide adequate leadership for students will have at least one member in five who has achieved professional distinction by creative activities. Such persons will (1) be conducting high grade research of an engineering or educational nature or other creative activity including publishing of good quality, (2) be engaging in consulting work at a creative level, (3) be exercising leadership in scientific, educational and professional societies or (4) preferably be serving in a combination of such activities. It is recognized that development is quite as important as selection of a faculty and also that a definite policy on termination of employment for those who do not live up to their expected performance is a necessary factor in faculty development.

Accreditation of Curricula

A request from ECPD brought the Committee on Evaluation into the discussion of accreditation. For proper handling of accreditation ECPD needs improved standards for measuring the effectiveness of the educational process and also criteria that distinguish engineering curricula from those in science and from those in technical institutes. As already indicated the Committee on Evaluation concluded that an increased background in mathematics, physics and chemistry, a study of nine engineering sciences, and a continuity of study of engineering analysis and design, or of engineering systems, extending through four semesters should distinguish an engineering curriculum intended for the training of engineers for professional-scientific service such as research, development or design. Then recognizing the need for additional engineers for general professional engineering services, the Committee concluded that a bifurcation in engineering education is the practical answer to such diverging functional objectives. It has, therefore, suggested the terms *professional-scientific* programs and *professional-general* programs to designate the two broad functional objectives of engineering education.

Professional-general programs are those designed for producing engineers qualified (1) to serve in areas between engineering and business, management, law, real estate, or agriculture, (2) between engineering and a branch of science where the opportunities to apply engineering analysis and design may be limited, (3) between engineering and a highly applied technology such as production processes, operation, construction, or air conditioning, welding, or wood technology. Such programs may have somewhat reduced requirements of mathematics, physics and chemistry, and only seven of the nine engineering sciences need be included. Also, the study of engineering analysis

and design may be reduced from four to two continuous semesters. However, the decision as to whether a planned program curriculum is really engineering education is to be made wholly upon its content of the engineering sciences and the use made thereof in the study of engineering analysis, design and engineering systems.

A decision has been reached by ECPD, upon the recommendation of the Council of ASEE, that the standards of accreditation of engineering curricula shall be raised. To achieve this result without undue hardship it is here recommended that the accreditation process be reconsidered on the basis of a distinction between *professional-scientific* studies and *professional-general* studies. Some institutions may choose one function or the other for all programs; other institutions may have a bifurcation between the objectives selected by different departments; and in large departments dual curricula serving different functions may develop. Bifurcation exists widely today in upper-division options, senior options, groups of electives or selective opportunity for research or thesis study. The Committee emphasizes the importance of broad experimentation with all such opportunities for selected engineering students. Each device mentioned can make a strong contribution to professional-scientific study.

The Committee on Evaluation recommends that each engineering college determine for itself the best way to meet ether or both of the dual objectives that the Committee has defined for engineering education. To ECPD it recommends liberal acceptance of experimental programs that meet the definition given of engineering education, i.e., those that include an adequate content of engineering science and of applications thereof to engineering analysis and design. The length of curricula should be one such factor subject to wide experimentation. The Committee does foresee difficulty in meeting within a four-year program its recommendations for an accredited professional-scientific engineering program plus all of the specialized courses of the degree-granting department, but it believes that specialized engineering courses are of far less value in professional-scientific education than a broad background of engineering science and its application is one field of analysis and design.

Special Designation of Accredited Curricula

There appears merit in identifying those curricula which meet criteria substantially above the minima. The major factor in such identification should be the background and eminence of the faculty and its attention to creative teaching. When the program conducted by this faculty is of such a nature as to develop in a considerable proportion of the graduates a capacity for creative technical activity or creative leadership in engineering it is the recommendation of Committee that this curriculum should be given special designation. For such designation curricula should be taught by faculties including a substantially larger proportion of distinguished staff members, as defined previously, than is required for minimum accreditation. The recommendation of a curriculum for special designation should be referred by the Inspection Committee for final action to a group of national representatives whose background of examination of institutions covers a wide geographical area.

Conclusions

1. By joint action of ASEE and ECPD the Education Committee of ECPD has been instructed to develop higher standards for accreditation of engineering curricula.

2. One objective of the Committee on Evaluation has been to establish a philosophy of engineering education appropriate to the training of engineers for leadership a generation hence, and to clarify the significant factors that contribute to high standards of engineering education.

3. Another objective has been to study the influence of higher standards of ac-

creditation upon the Engineering Colleges and to consider ways in which institutions may appropriately justify accreditation based upon the performance of different functions in the broad field of engineering education if they so desire.

4. The functional divergence so evident in engineering activities, which range from research to management and sales, has led to the Committee's recommendation that accreditation be based upon either of two defined functions in engineering education, i.e., *professional-general* education and *professional-scientific* education. Such divergence should not necessarily require separate curricula but might be based upon options, groups of electives, their study, etc.

5. In order that the decision to develop advanced standards of accreditation may not unduly restrict the number of possible accredited curricula, the Committee recommends that a special designation be given to any curriculum taught by a faculty of unusual distinction where the program conducted by the faculty is of such a nature as to develop in a considerable proportion of the graduates a capacity for creative technical activity or creative leadership in engineering.

Further Studies

The Committee on Evaluation has made the report summarized above as a *Preliminary Report* for study by each College of Engineering. Each of the recommendations tentatively adopted will be reconsidered in the light of the suggestions, criticisms and revisions presented by reports from Institutional Committees on Evaluation and Deans of Engineering Colleges. Resolutions from engineering groups will be welcomed although mere criticism or approbation without supporting analyses will not be very helpful to the Committee in revising its report into final form. Therefore, the Committee on Evaluation particularly requests thoughtful, mature analyses of the Preliminary Report without undue emphasis upon the form or mechanism of accreditation which is of secondary importance in this study.

Unionization of Professional Personnel*

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I shall endeavor to discuss this subject from the point of view of industry as I see it. Obviously I cannot speak for industry as a whole nor will the point of view which I give necessarily represent the complete and entire point of view of any manufacturer or groups of manufacturers, or employers of professional personnel. Since industry employs both engineers and scientists in many of its operations, very often in the same plant, it is proper to consider them together, although the chief emphasis will be on the engineers.

The Struggle for Unity Organization

There has long been an urge on the part of engineers and scientists to find some way to keep governmental agencies properly informed as to the advances in the fields of science and engineering. The professions of law and medicine exert a strong influence on governmental affairs as applied to their own spheres of activity. The engineers and scientists as a group possess special knowledge which they feel can be useful to the government at local, state and national levels and it is to be expected that the professional man will want to assist government to whatever degree he can.

On the other hand, there are matters of legislation of very considerable importance to professional people which with the exception of law and medicine, and to some degree the church, have not been well represented in the halls of Congress. It is well known that legislation affecting the practice of medicine will have the scrutiny of the Medical Association before it gets very far.

Beginning with the formation of the American Association of Engineers in 1915, there have been several organizations formed to work in the fields of activity covering all branches of engineering. These included American Engineering Council, the Engineering Council for Professional Development, and more recently the Engineers Joint Council. The Founder Societies were active in the formation of all of these. The AEC was in existence for eighteen years.

The objectives of EJC, which now has a membership of eight National Societies, including the Founder Societies, are:

"a. Advance the general welfare of mankind through the available resources and creative ability of the engineering profession.
b. Promote cooperation among the various branches of the engineering profession.
c. Advance the science and profession of engineering.
d. Develop sound public policies respecting national and international affairs wherein the engineering profession can be helpful through the services of the members of the engineering profession."

Registered Professional Engineers in the various States founded the National Society of Professional Engineers in 1934 with headquarters in Washington, D. C. Its voting membership is limited to those registered under the laws of the various

* Condensation of paper presented at the Annual Meeting, ASEE, Univ. of Florida.

States. Its objectives are given as "the advancement of the public welfare and the promotion of the professional, social and economic interests of the professional engineer." It has presently a membership of 28,000. Members are kept currently informed of activities through the N.S.P.E. Legislative Bulletins, and their publication *The American Engineer.*

Of this entire group, the two organizations who stand out most clearly today as being possible vehicles for meeting the objectives of the unity organization, are the National Society of Professional Engineers and the Engineers Joint Council. Neither of these organizations quite meets the desires of engineering people, which may be summed up in the following:

IMPROVE { Professional / Economic / Social } status

PROMOTE { interests of their employer or client / interests of their profession / general welfare of the professional employees }

SERVE { their community / society at large }

REPRESENT { engineering and scientific people in problems of local, state and national government }

Growth of Engineering Associations and of Independent Unions

After the Wagner Act (1935) and before the Taft-Hartley Act (1947), many professional persons became increasingly alarmed over the possibility of finding themselves in a heterogeneous union in which the professional people would be greatly outnumbered and persons controlling the union would not be likely to be sympathetic to problems of professional people. What could happen was demonstrated in many cases as documented by Raymond L. Forshay in a paper in 1946 presented to the ASME.

Engineering Associations (Non-certified)

The most extensive organizations of Engineering Associations which are not union groups are found in six of the larger plants of the General Electric Company, with a total membership of almost 4000. In the G.E. Associations, engineers at all levels may become members but those in supervisory or managerial positions do not in general take any active part. Generally speaking, their constitutions provide for "an organization through which the members may advance their professional, economic and social status and better discharge their responsibility to promote the interests of their employing company and their profession, and to serve their community and society at large." The largest of the Associations, which is in Schenectady, has been very active in promoting civic activities such as a housing project, traffic control, transportation and many other matters which have been of distinct benefit to the city of Schenectady.

There are associations in other companies which have objectives that are similar.

These Associations have in general kept their members informed of the salary situation through salary surveys and have also provided useful data resulting from attitude surveys which some of them have conducted. The ideas of the General Electric Associations on Unity have been incorporated in an article appearing in *Electrical Engineering* for April 1953, entitled "A New Unity Plan Proposed."

Unions Set up for Protection

Perhaps typical of the unions formed to prevent being drawn into a heterogeneous group are the unions organized at the Western Electric Kearny Plant, TVA and Sperry Gyroscope. Some of the unions so organized still retain their autonomy while others have joined the newly organized Engineers and Scientists of America, which is now on a National basis. Some have operated very much as they did before they were certified. Others

have been more militant in their dealings with their managements, operating to negotiate grievances and using the machinery which is normally associated with labor unions. This was, of course, a natural development even though organized originally as a protection against a labor union.

Unions Set up for Bargaining Purposes

Unions in this category were established primarily because of what they regarded as being unsatisfactory practices of the employers. Some of the practices listed as being unsatisfactory are: Loss of economic position in comparison with labor; no premium pay for overtime; too little personal recognition by supervisors; use of engineers for semi-technical jobs; lack of planning for the development of young engineers to increase their effectiveness and to utilize their particular talents; inadequate measures taken to prevent loss of dignity and failure to maintain professional standing; failure to provide adequate channels of two-way communication; inadequate and undesirable offices; lack of secretarial and drafting assistance; punching clocks; checking by plant guards when coming in late.

Situation is Greatly Improved

Many companies have given much time and effort to determine what is right and proper in terms of compensation, job satisfaction, dignity, professional recognition, opportunity for position development, clear understanding of mutual problems, better two-way communication, use of professional personnel up to their full capacity, further development of individuals through courses both within and outside the Plant, together with proper facilities for doing the work assigned. These, together with realistic and satisfying insurance, pension, investment and savings plans, as well as freedom from unnecessary restraints, are designed to relieve the professional employee from frustrations and worry so he can do his best work and progress as far as his ability and desire can take him. These are the goals of enlightened industry today with respect to their professional personnel.

In industry whose product is such that the engineering content is great, the supervisors and managers are usually engineers themselves, and have the engineering approach and point of view. The EJC Survey of 1946 indicated that over 30% of the technical graduates reported their field of employment as either in administration or management. There is a wealth of other data indicating that engineers are widely used in managerial positions. In such enterprises the professional will also be found in the manufacturing and marketing operations. Thus the engineer, either through the developments he may make, the new and novel designs he produces or the new molecule of which the scientist may be the architect, may well have such an important effect on the business that he truly becomes a part of management although he himself may not be a manager or even a supervisor.

How can the engineer be taken into the confidence of management with reference to problems where the engineer's knowledge or judgment is important to the business, if the manager knows that such information could be of great value to a union for propaganda or bargaining purposes? This cannot help but build a wall between the professional personnel and their management. When the union is a local and independent one this may not be a serious matter, but for confidential information to become available to National union leadership who have no particular sense of loyalty to a given plant, and who may even be antagonistic to its management, would be most unfortunate. Under such conditions management would tend to protect itself by not taking its personnel into its confidence as it normally can do with its professional people when they do not belong to a National union. There are engineers in employments where the above statements do not apply because they are not consulted on

policy matters or their work is of such a nature that they do not have access to confidential matters. In some cases it will not apply to young engineers until they have established some reputation for accomplishment.

Ethics

The engineers no more than the doctor or lawyer can serve two masters. Like the doctors and the lawyers the engineers and scientists are a group of intelligent people capable of speaking for themselves and disliking regimentation or compulsion. They believe that the treatment accorded them should be like that given to doctors and lawyers, and they are right. On the other hand, they must show that they are worthy of the trust placed in them, and that they will conduct themselves in a manner befitting a professional man who places the interest of his client or patient first and who will do nothing while employed by him to hurt his interests. The professional knows, or should know, that no business can prosper without profit—that a reasonable and proper amount of money should be reinvested in the enterprise in order to retain a satisfactory percentage of the available business. He knows also that the product must be improved continually, new products developed and cost reductions achieved constantly; otherwise the company will go out of business. These are matters of economic operation and along with other items are the concern of the engineer. It is his responsibility in many companies to maintain the quality of the product and to assist materially in reducing complaints. He must do all he can to protect the interests of his company in design, in manufacturing, in the marketplace, or wherever he may be.

Ethical practice may be difficult within a local independent union, or association as they are frequently called, but with a National union the opportunity and temptation for unethical practice will become even greater, particularly where competing company employees are concerned, or customers' and vendors' employees are involved. The engineer is often entrusted with developmental information relating to new products or improvement of existing ones which may be of very great value to his company, and where premature disclosure could have disastrous effects. Such information is the property of the employer and should not be disclosed nor should it be a matter of or related to any bargaining issue. There are many problems to be solved in this area by the national union when it has in engineers and scientists from all kinds of industry, together with a smaller percentage of nontechnical people. This is not to state that the National union cannot be ethical or that it is inherently unethical, but it is to say that as more and more power is concentrated at the top the stakes become higher and the temptation greater to feel that the ends justify the means.

Effect on Technical Societies

The effect will be determined to a considerable degree by the future growth of Engineers and Scientists of America (ESA) or equivalent union, and the changes the unions or technical societies may undergo as a result of experience and the passage of time.

The injection of another national organization (ESA) with the stated objective "to promote the economic, professional and social welfare of engineering and scientific employees" adds to the already complicated picture of unity organizations.

Since ESA is a union group it is different from any of the other societies in that it automatically excludes managers and supervisors from its membership. It is also different in that scientists are included. It is to be noted in this connection that engineers and scientists are often employed in the same laboratory or plant. However, many scientists belong to the engineering technical societies because of a community of interest in certain fields. Scientists are included in the membership of both union and nonunion associations in many locations.

The stated objectives of ESA are very similar in essence to those of the American Association of Engineers and the National Society of Professional Engineers except that ESA is limited to employees. ESA has in its scope some of the functions of the EJC.

It would appear, based on objectives, that EJC, NSPE and ESA are all in a somewhat competitive position with respect to legislation as it affects the engineers. This applies in areas outside the strictly technical.

Those who have the welfare of engineers and scientists at heart should make it their business to give this whole matter serious and unbiased study, because trends may be established now which could not be changed a few years hence. Let's be sure of how we want this unity program to develop. There are those who would combine all activities in one society, to avoid duplication of effort, payment of dues in two or more societies and to avoid attending several sets of meetings in order to get the complete program.

Some of the difficulties of operation with groups more or less in competition is indicated when one considers the operation of committees in the technical societies or National Society of Professional Engineers who may have in their membership persons who are also active in ESA, thus making the problems of living together increasingly difficult. This could result in supplying channels of information either into the technical societies or into ESA which might be used in a manner inimical to the interests of the groups involved.

Professional Employee Relations

In this paper there will be no attempt to present a complete story dealing with all the problems of management with respect to the professional employees. Some of the more important ones, however, will be discussed briefly.

Whether in our colleges or universities, in industry or in government, to produce job satisfaction on the part of the employee it is necessary that his management not only understand but practice good professional relations. Job satisfaction includes many factors, one of great importance being compensation. In this brief discussion of compensation I will limit myself to the problem as it exists in industry.

The larger enterprises, and many of the smaller ones, who are concerned about their professional people have given a great deal of time and effort to setting up salary policies which will be fair and just, with all determining factors considered. The compensation which a new professional employee without previous service receives is necessarily a payment for potential. As the years pass, however, the compensation is based to an increasing degree upon his demonstrated contribution. Obviously the contribution which a man may make to the operations carried on by his company can and in many cases does continue to increase through the years as long as he remains with the company. On the other hand, it does not necessarily follow that because he is older his contribution is greater. In many companies, salary reviews are conducted at stated intervals, perhaps once a year, after having made a careful appraisal of each individual and his accomplishment, but it should be possible to make salary adjustments whenever warranted in special cases.

Survey data such as in the 1946 Survey made by EJC, and other surveys made by groups of employers or by technical societies, as NSPE or the various Engineering Associations are useful and should be properly consulted and compared with the salary structure in a given company. It is important to be as sure as one can be that the compensation is right and proper for the individual involved, with due consideration being given to the compensation received by others in his own group, or in other groups requiring similar skill or experience in his own company, as well as comparison with data received from outside. The professional

employee feels that a merit increase is a measure of his improved performance, his better output or his ability to handle increased and more complex work, and is given to him in recognition by his employer of this improvement. Increases that come to him as a result of other factors which may be general increases not based on merit are, of course, very acceptable and if not received would be cause for complaint.

Some sort of rating system or its equivalent has proven to be very helpful in the matter of appraising an individual. It also provides a good opportunity for his supervisor to discuss with him his opportunities for advancement, his contributions, his personal qualifications and

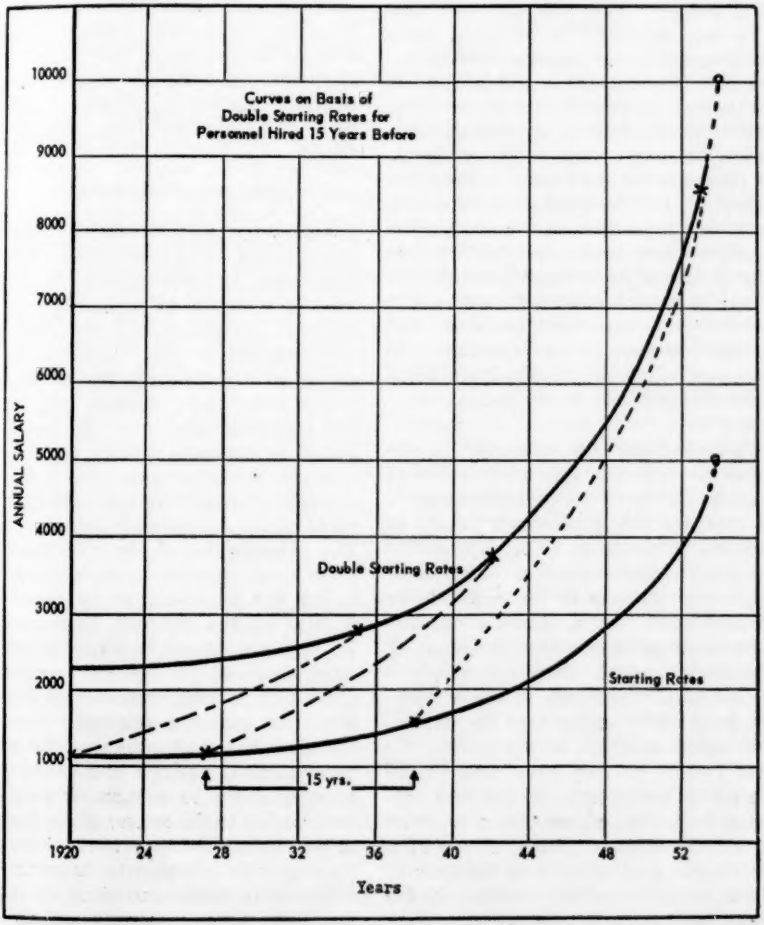

FIG. 1. Starting rates for engineers—showing curve of increase when salary is twice the present starting rates after fifteen years of service.

any unsatisfactory situations which may have arisen, and to indicate to the employee what he himself might do, and what the company might help him do to improve the situation. Such interviews should be conducted frequently. The supervisor and the employee should welcome the opportunity for a heart-to-heart talk concerning any matter which is on the mind of the employee, but aimed particularly at the employee's question "How am I doing?" This does not mean that the contact should be limited in any sense. The professional employee should always feel that his supervision will be glad to talk matters over with him at any time, whether in the field of his own personal affairs, his relationship to the company, his prospects for the future or any other matter. It is not enough that the supervisor merely be able to call the professional employee by his first name and to make it easy to have an interview, but he should be sure that the employee understands that his supervisor has a real and personal interest in his happiness and well-being. He must be willing to demonstrate this attitude in his actions as a supervisor.

In connection with compensation, the curves shown in Fig. 1 are of considerable interest. The lower curve shows the starting rates for B.S. graduates beginning in 1920 and projected to 1954. Up to 1953 this is an experience curve. Whether or not it will continue to the point shown for 1954 is, of course, unknown, but it is rather amazing to note how these starting rates have increased. Bearing in mind the present economic picture in our country, one could hardly expect that the starting rates could continue to increase in the same fashion as they have done in the last ten or more years. It has been suggested in various places that a criterion for determining the present salary of a professional man could be on the basis of at least twice the present starting rate for a man who has had fifteen to twenty years service. To see how this works out the upper curve was drawn in Fig. 1 on the basis of indicating double the starting rates throughout the entire period. Curves have then been drawn showing a possible salary increase picture for an individual who entered employ in 1938 and in 1953 would be expected to receive at least twice 1953 starting rate. The curve for such an individual is almost asymptotic. It will be immediately apparent that such a situation is unstable and certainly cannot be expected to continue very long without reaching some rather astronomical figures. I am not making any predictions whatsoever as to the future, but I think it is clear that these figures cannot continue to rise at the increasing rates of the past without the economy being seriously affected.

Two-way Communication

The channel of communication between the employee and his supervision must be kept open. First the employee must know what is expected of him. He must be properly oriented with respect to his supervision and his fellow employees. He should be kept well informed of the company's procedures, practices and policies, and how they affect him. His questions should be answered directly and immediately by the supervisor, and if he does not know the answers they should be secured within a reasonable period of time. The potentialities of the man should be given every opportunity to develop to the fullest and he should be appraised frequently of the progress he is making. Worthy goals should be set up for him to strive for, and then proper recognition given both in compensation and in position. In highly specialized operations there will be need for the specialist whose compensation, position and professional standing should be commensurate with his contribution to the success of the business as well as in the improvement in the art. Policies with reference to improving his education in those areas which are of mutual value to the company and the employee should be given very careful consideration and where arrangements can be

made reasonably, this should be done in a manner satisfactory to both employer and employee.

Some people work well under pressure and others may not. The idea that developments may be scheduled with exactness would depend upon the state of the art and what might be the nature of the development. There has been recognition of this in the separation of the scientific personnel engaged in purely scientific research from personnel primarily concerned with production. This does not mean that goals should not be set up and dates attached, but supervision ought to understand and be sympathetic to reasonable operation for the scientific personnel.

More and more professional people work as teams or task forces to solve the problem, because the background has in many cases become so great that one individual cannot be sufficiently expert in the many fields involved. Design problems are much closer to production—dates and specifications must be met. The engineers must be able to work with the customers in many cases, with the manufacturing organization, sales or marketing groups and produce a design on which the employer can make a reasonable profit. Such factors as these are all important to the operation of the business and must be discussed frankly and freely with employees, through the medium of two-way communication. The employee will get the sense of belonging to the company if he is taken into confidence and informed of impending changes which may even remotely affect him or his operations. This can be done individually or collectively with groups, depending upon the nature of the problem. Many companies today are holding informative meetings frequently, sometimes in large groups when dealing with overall company business problems and matters of that sort, and even more often in smaller groups when the problem being discussed is one of a local nature or one which requires more intimate contact with the engineers and scientists.

Activities of this sort take considerable time and they have to be reasonably well planned. Yet they do make for good job satisfaction. I know engineers who have been employed for periods as long as five years to whom their company's plan for insurance or pension has never been explained; neither have they received any written material relating to it. Many companies are doing a good job in this area, but it is an important field and should be given very serious attention.

Summary

1. There has been a strong desire on the part of the engineers during the past 30 to 40 years for the development of an organization which can speak for them in relation to government, which will do whatever is necessary to maintain the professional standing of the profession, set up in such a manner that its members may feel a personal and active relationship to such a unity organization, with an operating mechanism which is reasonably quick and will represent all engineers of every branch in all matters of concern to the engineers.

2. The growth of the Engineers and Scientists of America, which is a federation of labor unions, represents the entrance of another group into the unity picture, and its possible relationship to existing technical societies, groups like NSPE, AAE and Engineering Associations requires very careful study and consideration. People in these various groups will be interested in studying this whole situation to discover what these trends mean and what future action ought to be taken to get the best result. If ESA grows to large proportions it can constitute a serious threat to the existing Societies.

3. The existence of a national trade union of engineers for the purpose of collective bargaining, using the usual union pressure techniques, is almost certain to produce profound changes in the professional status of engineers if the venture is successful. While there are isolated small and exceptional instances

of trade union organizations in other professions the trade union principles of militant, collective action are in many respects inconsistent with the principles of the professional engineer, doctor or lawyer which emphasizes individual competence, integrity, and the confidential relation between the professional and his client or employer.

4. There are many situations in existence today in the various employments in industry, in government and in our educational institutions where professional employees are not being given the consideration now being thought desirable and necessary by the more enlightened industry units. The following thoughts may be of value to you in this direction:

a. Be sure that you are giving your engineering and scientific personnel compensation which is just and fair, and be certain that you are familiar with what others are doing in this area as a check against your own thinking.

b. Give your professional people the attention which they and their problems deserve.

c. You cannot operate in a vacuum—your communications must be good both ways. Your supervision may not be as good as you think.

d. Avoid misunderstandings. Be sure that your supervision has a clear understanding of his own responsibilities and accountability.

e. Realize that your professional employee wants recognition not only from the salary or compensation point of view but as a professional individual who carries a real responsibility and who in many cases can grow in his contribution if given the chance and backed up with faith and willingness to help on the part of an immediate supervisor. To be as successful as we can be, we should continually strive for job satisfaction. Be certain that your professional people are used up to their capabilities, that their contribution and potential is properly evaluated, that the employee is kept informed, and that his compensation is right and proper both from the standpoint of his own group and company as well as on a community and national basis.

College Notes

Paul F. Chenea has been named as Assistant Dean of the five engineering schools of **Purdue University.** In his new capacity, Dr. Chenea will assume such administrative duties as may be assigned by G. A. Hawkins who became Dean last July 1.

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George Gerard has been appointed Assistant Director of the Research Divisions of **New York University's** College of Engineering. The Research Division, with a staff of 405, has an annual operating rate of more than $2,000,000 in research sponsored by industry and government. . . . Emanuel A. Salma has been appointed Acting Director of the Evening Division of the College of Engineering at **New York University.** He will administer the educational programs of 1,130 students who are studying for degrees in major branches of engineering while employed in engineering work during the day.

• • •

The **University of Pittsburgh** has let contracts totalling $1,195,087 for the construction of a building to be a new headquarters for its schools of engineering and mines.

How Can Competent Young Instructors Be Attracted to Colleges? What Intangible Rewards Are Available?*

By WEBSTER N. JONES

Vice President, Carnegie Institute of Technology

One of the critical problems that continually haunts engineering college administrators is how competent young engineers can be attracted to teaching, and as a corollary, what intangible rewards may be stressed in lieu of high salary.

First on my list of criteria for attracting good teachers, I would place leadership—the need for an enlightened, progressive and respected central administration, dean, and department heads. There is no need to spell out the reasons why good leadership is essential; I'm sure you all agree with me on that point. But I would like to interject one word of caution. In so far as may be possible and practicable, I would warn against too frequent turnover at the department head level. It takes a long time to develop a good department head, and a longer time for him to develop the type of intimate morale which goes beyond what can be found in industry and makes membership in his department appeal to the finest type of young man. Many faculty members just do not have the required abilities to be an administrator, as well as to direct and take part in teaching and research. In any case, I would recommend that department heads be appointed rather than be elected by their colleagues at recurring intervals.

Secondly, I would be concerned with educational objectives, and the general policies and procedures used to achieve them. If a man is to give up the greater financial rewards of industry, one of the strongest reasons for doing so will be his love of teaching, and his faith that in the institution where he will teach, teaching can be made enjoyable and deeply worthwhile—a greater service to his country than he could give in any other way or any other institution. "Sound educational objectives" implies preparing the student to continue to learn for the rest of his life as a person, a citizen, and a professional man; and although there may be many satisfactory routes to achieve these objectives, few promising young teachers will be attracted by a philosophy of stuffing the student with knowledge and techniques as contrasted with the philosophy of educating the young to become better.

Assuming that we are talking about an institution that is primarily undergraduate, I would nevertheless insist on having a quality graduate program and the vitalizing influence of research. Every staff member must in general expect to share the opportunity to teach graduate courses and direct research in his field of special interest, so that he can find a higher intellectual satisfaction at the cutting edge of progress in his field than industry can provide. Of course, the faculty member should also be encouraged to participate in part-time consulting work, and in the activities of technical and professional societies.

*Presented at the Annual Meeting of ASEE, University of Florida, ECAC Program, June 1953.

Character of Staff

Next in importance, I think, concerns the character or make-up of the existing staff. The most valuable natural resource of any organization, and perhaps its greatest source of pleasure and development, is the young engineer who comes to it. Indeed, to many a man in industry, the primary appeal of the educational institution is the intellectual personal quality of its staff members. A young man wants to be stimulated by competent leaders in his field, and he wants to work in an environment that encourages his professional development, and that also delights him by the human contacts it provides.

Then *fourth,* I would want adequate space and equipment. It is all too easy to give lip-service to the necessity for research, and yet not provide the facilities that are required to do the job. True, graduate work and research are expensive. Yet they must be done, if only to improve the quality of the undergraduate education. Enlightened leadership will find ways to provide the space needed for research and adequate equipment, too. The expense can be minimized through a carefully planned and administered program of sponsored research. And much good fundamental research can be carried out in existing undergraduate laboratories.

Fifth, though not necessarily last, adequate salaries must be paid, especially for outstanding men. The generally prevailing rates of faculty compensation are dismally low compared with salaries paid by industry to comparable personnel. I doubt if there are any schools that have been able to keep their salaries moving with the increased cost of living in the past ten or fifteen years. We must do much more, if we are not to lose our best people to industry. Fortunately, there will always be those who will prefer the university atmosphere and the attendant advantages and opportunities. But that is no excuse for holding salaries down, and it cannot be relied on without danger, especially of losing the best men. Every effort should be made to pay better and better salaries, and to avoid routine personnel attitudes that lead to even rates of promotion. Instead, education must equal or surpass industry in recognizing and advancing rapidly its key men. They are the ones to fight for. "The poor (and even the merely competent) we will have with us always."

Conclusion

There may be other factors which contribute to the appeal of an educational institution—for instance the quality of the students admitted—but I think in essence we have mentioned the most important. Of this I am sure—if the institution has good leadership, if it has sound educational objectives and standards, if it has a highly competent staff, if it has ample facilities and pays adequate salaries to good men and outstanding salaries to the best no matter how young, then it will have less difficulty in attracting new faculty members of outstanding promise and in keeping them.

Future Scientists of America Foundation—Its Work and Objectives*

By HENRY H. ARMSBY

Member of Administrative Committee FSAF

Before this audience of engineering educators and employers of engineers, there is no need to call attention to the current and prospective shortage of engineers, scientists, and technicians. You all are thoroughly familiar with the various estimates which have been made, which, while they differ in detail, are all in agreement that the shortage is a serious one, and that it can be expected to continue for many years.

A *New Forecast of Engineering Graduates*

In my latest attempt at forecasting numbers of engineering graduates, prepared for a recent meeting sponsored by the Research and Development Board, I computed engineering freshmen as a percentage of all college freshmen, and found that the percentage reached a 20 year low of 6.6 per cent in 1950. Last fall it was 9.7 per cent, compared to a general 20 year average of 8.0 per cent. If we can maintain the 8 per cent ratio, the increasing sizes of the groups of young persons reaching college age should yield, according to my estimates, from 26 to 30 thousand engineering graduates per year beginning in 1956, when the present freshmen class graduates, provided no basic changes are made in Selective Service policies or in other basic factors affecting enrollments.

* Talk delivered before the General Session of the American Society for Engineering Education, Gainesville, Florida, June 25, 1953.

Probable Civilian Supply

These are estimated total engineering graduates, but the inroads of Selective Service and ROTC programs will leave only a fraction of this number available for civilian employment.

Last fall I served as a member of a subcommittee of the ASEE Manpower Committee which attempted to estimate the number of engineering graduates who would be available for industrial employment through the period 1951–56 under two alternate assumptions; (1) a continuation of present conditions of partial mobilization, and (2) all-out war in 1954. We estimated about 118 thousand available under present conditions, and 31 thousand under all-out war in 1954. At the BLS "partial mobilization" rate of 30 thousand per year, the total need for the six-year period will be 180 thousand. What it will be under all-out war conditions no one knows, but certainly it will be much larger.

The second annual report of the National Science Foundation contrasts this picture with their best estimate of conditions in Russia. According to this report, the USSR has enjoyed a steady climb since 1945 in the production of engineers, and their plans call for 50 thousand a year by 1955. Furthermore, these Russian engineers are for the most part graduates of five-year curriculums, and some of six-year programs.

A Long Range Program Indicated

These few figures are given to indicate part of the reason for the establishment

of the Future Scientists of America Foundation. Even a brief study of the figures indicates that the problem of the shortage cannot be solved at the college level alone. Anything done at this level can be only a short range and partial answer. The long range problem can be solved only by considering high school youth, especially those still uncertain about future careers but possessing aptitudes and abilities indicating probable success as scientists, engineers, or technicians. The problem then becomes one of identifying the students with these abilities and aptitudes, giving them sound and unbiased career information, using effective motivation so that they may seek to make the most of their native abilities, and providing such instruction in junior and senior high schools as will give these youth the proper foundation for successful study of engineering, science, or technology in colleges or technical institutes.

The importance of this kind of a program can be appreciated when we realize that approximately 40 per cent of those high school graduates who have the ability to do successful college work (the top 15 per cent of the total high school population) do not go to college at all. If some of these capable students can be helped to consider seriously their own abilities and interests in relation to the Nation's needs for scientists, engineers, technicians, and science teachers, then the general situation in these fields can be improved without endangering the development of manpower for other fields. More and more leaders working on manpower problems are accepting the idea that special efforts to improve and expand the teaching of science and mathematics in junior and senior high schools are greatly to be desired.

The May 1951 Institute sponsored by the Thomas Alva Edison Foundation brought this critical situation to the attention of leaders in secondary school science teaching. They immediately associated these problems with those posed by a decreasing percentage enrollment in high school physics and advanced mathematics courses, the small number of college students preparing for careers as science teachers, and the loss of active high school science teachers to military service or to more remunerative positions in industry. Here was ample motivation for planning a carefully organized effort to increase the numbers and quality of high school science students and science teachers.

How Was the Foundation Planned?

The National Science Teachers Association has had for many years an active Committee on Professional Relations and Projects. This Committee, using its earlier experiences and proposals developed preliminary plans for a program geared to this situation. The Board of Directors favored the plan in principle and authorized a protem committee for further planning. In February of 1952 the Board approved the broad outlines of a plan, which in March was placed before representatives of 19 major national organizations concerned with scientific and engineering manpower problems. A series of meetings were held, and the proposals and plans were progressively revised and clarified. Twenty industrial companies made modest grants to cover expenses incident to the developmental work. Finally in July of 1952 the Board approved the plans and appointed an administrative committee to carry forward the development of the new organization. This committee still further refined the plans and proposals until January, 1953, when stage I of the Foundation's plan was actually launched. I shall come back to this a little later.

The names of the Administrative Committee may be of interest to this audience. They are, in addition to myself:

Dr. Allen V. Astin, Director of the National Bureau of Standards

Mr. Hugh E. Brown, Educational Chart Editor, W. M. Welch Manufacturing Company

Mr. Robert H. Carleton, Executive Secretary, National Science Teachers Association

Dr. Charlotte L. Grant, Dean of the Junior Class and Instructor in Biological Sciences, Oak Park and River Forest High School, Oak Park, Illinois, and President Elect of the National Science Teachers Association

Dr. Philip G. Johnson (Chairman of the Administrative Committee), Specialist for Science, U. S. Office of Education

Dr. Milton O. Lee, Secretary-Treasurer, Federation of American Societies for Experimental Biology

Professor Ralph W. Lefler, Assistant Professor of Physics and Education, Purdue University

Dr. Harold E. Wise, Assistant Dean of the Graduate College and Professor of Education, University of Nebraska, and President of the National Science Teachers Association

This Administrative Committee will be seen to be broadly representative of the physical sciences, engineering, biological sciences, high school and college teaching, and science teacher education. Further representation for scientists, engineers, and industrial leaders is provided through a board of consultants composed of persons designated by sponsoring and advisory groups. This board is now being developed and already includes official representatives of ASEE, of the Engineering Manpower Commission, and several other groups.

This brief history of the origin and development of the Future Scientists of America Foundation has been given in some detail to emphasize the fact that people representing all the major agencies concerned with the general manpower problem have been consulted time and time again, and their ideas thoroughly considered in the planning and development of the Foundation. This undoubtedly explains why the Foundation has been able to win the wide endorsement which promises the financial support and generous advice necessary for a really constructive action program.

What Is the Plan?

The Foundation recognizes six elements in the over-all situation, some of them problems, some of them means toward a solution. These are (1) an expanding economy based on progress and preparedness, (2) shortages of scientists, engineers, and technicians, (3) a serious decrease in the number of well-qualified high school science and mathematics teachers, (4) falling enrollments in senior high school physical sciences and mathematics, (5) expanding science enrollments in grades 7, 8, 9, and 10, and (6) a developing elementary school science program. Involved in the over-all situation to a greater or less extent are about 25,000 high schools, 65,000 science teachers, and 4 million science students.

Considerable study was given to the proper name for the organization which seemed called for under the general conditions prevailing. The name finally chosen was the Future Scientists of America Foundation. Each word in this title was carefully considered, and legal counsel was available before the final decision was made. It was decided that responsibility for the organization had to reside somewhere, and that there were many reasons for making it an activity of the National Science Teachers Association. One reason was that as an official department of the National Education Association, chartered by the Congress as a scientific and educational organization, it has exemption under Section 101(6) of the Internal Revenue Code. Incorporation of the parent association also applies to the Department; therefore, no separate acts of incorporation were necessary. The fact that the Association is an affiliate of the American Association for the Advancement of Science was also believed to be of considerable value.

The purposes of the Foundation are basically two, namely to help *all* high school youth understand the basic principles of science, engineering, and technology; and to help *able* high school youth to become interested in and to prepare

for careers in these fields and in science teaching.

The fields of action for the Foundation were selected after careful study, and even now they still represent *proposed* fields of action. They are (1) coordinating and strengthening curricular information and guidance services for high school students, (2) developing and extending science achievement awards for high school students, (3) expanding and improving specialized training opportunities for high school science teachers, (4) encouraging and managing awards to outstanding high school science teachers, and (5) promoting research on problems of high school science teaching. It was and still is the judgment of the leaders in science teaching that these are worthy of serious consideration, but they also wish possibilities to remain open for further suggestions.

The *methods* are also proposed. They are (1) cooperation in providing a source for helpful information; and (2) operation when after careful study it seems desirable to supplement what is already in existence.

The first need of the Foundation is for an executive staff to help advance the plans. The second need is for funds to provide for the operation of projects and for the expenses of consultants and committee members who guide the projects. We have no immediate need for funds for office space and furnishings, which are being provided by the National Education Association. We ask for no funds for the Administrative Committee, the members of which are glad to donate their services to the Foundation as long as actual expenses are underwritten.

How Is the Plan Related to Existing Services?

The basic purpose of the Foundation is to secure for junior and senior high school science students and their science teachers services which will be comprehensive counterparts to the existing and planned services directed primarily at college and postgraduate levels. With this in mind, two-way relationships have been established with the Engineering Manpower Commission, the Scientific Manpower Commission, the Manufacturing Chemists Association, the National Science Foundation, and the American Society for Engineering Education, and will be extended to other organizations interested in the over-all purposes of the Foundation. It is our purpose not to attempt to replace any agencies now working in the general field of the promotion of science and engineering, but rather to supplement and coordinate their efforts so that there may be a continuous endeavor extending from the elementary school through the secondary school and the college up to and including postgraduate levels.

What Activities Are Now Under Way?

The Foundation has been in actual operation for several months. We are now concluding the second year of an Awards Program for junior and senior high school students and science teachers sponsored by the American Society for Medals, and we are laying plans for the third year, for which funds have already been assured by the Society.

A report of this activity for the current school year shows that 50,000 posters announcing the program were distributed through junior and senior high schools in the early fall. Replies from about 1300 of these schools have asked for 18,551 student entry forms and 2500 teacher entry forms. Student entries numbering 847, but representing over 1000 students because of group projects, and 46 teacher entries are now being studied, and the actual awards will be made early next fall during American Education Week. There will be 104 monetary awards to students, 20 monetary awards to teachers, and certificates to individuals, medals to winners, and plaques to schools.

What Acitivity Is Soon to Be Launched?

A meeting with about 15 potential industrial sponsors was held in December

1952. This led to a brochure and an invitation to provide funds to underwrite a budget of $35,000 for stage I of the Foundation's program. The invitation for support has so far been extended to about 40 sponsors and contributions have been received from 11 of these, totalling $10,150. A secretary has been employed to assist in launching the project and to carry forward plans for extending the number of invitations.

Stage I involves the development of an inventory of incentive programs, career information, and services and specialized training opportunities now available or planned for high school science students and teachers. An inquiry form to secure information pertinent to the project has been developed through the assistance of a group of persons who met in Washington in April. This has been mailed to a selected list of teachers and schools. Another form to societies, industries, and other agencies has also been developed, based on suggestions of the same group of persons, and has been mailed to a few organizations for pretesting. Information received through the use of these two inquiry forms will be supplemented in developing the inventory list. We expect to have a full-time project director on the job in August for a period of at least six months. He will, with the aid and advice of the administrative committee and the representatives on the Board of Consultants, make a thorough study of this material and a re-appraisal of the problems and the means and methods for solution. Plans for future activities of the Foundation will then be based on a reasonably accurate and complete knowledge of current and planned activities and services.

What Will Follow as the Foundation Develops?

The five major project areas which I have mentioned will be restudied in the light of the findings of the inventory. We are making no firm commitments at the present time as to future activities of the Foundation. It is certain that if the current general impressions about the manpower situation and the available services are substantiated, there will be continuing activities of the Foundation. It is my personal judgment that the study will reveal a need and a desire for certain types of continuing services for high school science students and their teachers. However, we are holding these ideas as opinions for the present, awaiting the results of the study, which we believe is the way we ourselves can follow scientific methods and attitudes as we face the problems of improving science instruction.

Summary

The Future Scientists of America Foundation is based on the assumption that the best way to improve the long-range supply of engineers, scientists, and technicians is to increase the numbers of qualified boys and girls coming out of our high schools with adequate preparation for good college or technical institute work in these fields. We hope to do this through guidance services to students and teachers, through award programs, and through other activities. The plan has been developed through wide consultation with many interested individuals and organizations. The Foundation is an activity of the National Science Teachers Association, operating under an Administrative Committee with the counsel of a Board of Consultants. Five important areas of activity have been proposed, but thus far only one, an Awards Program, is in operation. Even here four additional programs are envisioned. The second activity, which is now starting, involves the development of an inventory of incentive, guidance, and specialized training opportunities for high school science students and their teachers. We are making satisfactory progress, although still incomplete, with the underwriting of the budget to maintain the Foundation and we are developing two-way relationships with several major groups concerned with high school

science teaching. We believe that the progress thus far made gives promise of further developments which will merit the respect and support of high school science teachers and administrators, as well as of leaders in industry, research laboratories, foundations, educational institutions, and other agencies. The suggestions and criticisms of members of the American Society of Engineering Education are invited, and your help in the projects will play a large part in determining how effective the Future Scientists of America Foundation will actually prove to be.

Accreditation of Engineering Curricula

A one-year trial cooperative program between regional and professional associations which evaluate colleges and universities has greatly improved accrediting procedures, according to Ewald B. Nyquist, secretary of the Middle States Association. He based his findings on a program between the MSA and the Engineers' Council for Pressional Development.

The MSA's Commission on Institutions of Higher Education is collaborating with ECPD and 25 other professional accrediting agencies. Mr. Nyquist spoke at an accrediting panel in a joint session of the American Society for Engineering Education and the ECPD at the Hotel Statler, New York City. Four hundred engineering, educational, and industrial leaders attended the four-day meeting of the two organizations.

Describing the program of the MSA and the National Commission on Accrediting, Mr. Nyquist reported progress in reducing abuses in accrediting. Among these evils, he listed the duplication of functions, excess number of accrediting bodies, destruction of institutional rights and power, excessive costs, superficial quantitative standards, and detrimental enforcement policies.

Principles in the Commission's activity, Mr. Nyquist said, include the following:

1. That improvement of higher education is best achieved when based upon self-evaluation prior to examination by outside specialists.
2. That an acceptable program of accreditation should be fostered on a nation-wide basis, and
3. That accreditation should exist primarily as a stimulus to institutional growth and development rather than merely a standardization based upon minimum criteria.

In evaluating institutions with engineering units, the MSA draws on the ECPD for expert personnel. ECPD reports are included in total evaluation reports. Cooperation also extends to questionnaires, schedules, exchange of confidential information, and costs billing.

The cooperative evaluation program, Mr. Nyquist said, should result in more effective development of engineering schools and curriculum. Further, he stated, "ECPD will be provided with an additional opportunity for interpretation of engineering education to educators in other fields and to other departments of a complex institution."

How Can We Instill in Our Engineering Students a Desire for Continuing Self-Improvement?*

By JOHN W. SHUPE

Assistant Professor of Applied Mechanics, Kansas State College

Upon the completion of a four-year college program, the normal engineering student will find that only half of his course work has been taken in the School of Engineering. Suppose that it were possible in those two short years to have exposed this student to all of the technical knowledge available in the field of his specialization, in addition to his basic engineering work. Assume further, that he was capable of retaining this vast quantity of information. Still in a comparatively short time, this student will discover that it is essential for him to continue his studies if he wishes to remain informed on the current advances of his profession.

To consider the subject from a somewhat more practical viewpoint, two years of training is insufficient to develop a professional engineer. The most that can be expected from college training is the essentials of a fundamental education; and continuing growth in knowledge, judgment, and technical skill is necessary to approach and maintain professional status.

In either case, it becomes apparent that a student's training must not be terminated by the conferring of a degree. There is no once-and-for-all education for an engineer. Therefore, it should be the primary aim of our instruction to develop in the student not only the ability, but, equally important, the desire to continue independently in his search for additional knowledge, and for the solutions to unfamiliar problems.

In analyzing our present methods of instruction, it might be well to review the general trend of engineering education. Before World War I the type of training which an engineering student received was for the most part designed to equip him for empirical engineering practice. There was very little theory presented, and the college graduate was an accomplished "hand-book" engineer.

A little later, the possibilities of theoretical analysis were recognized and incorporated into the engineer's college training. Shortly afterwards it was realized that an engineer must be qualified to handle people, so a place was found in the majority of curriculums for some humanistic courses. Finally, it was generally agreed that an enigneer must have a well-rounded personality and a broad outlook, so provision was made to include some form of general education.

Technical Advances

While this trend has been taking place, new technical advances have occurred, and new methods and procedures developed which have also been included in this four-year training period. As a result, in the endeavor to teach more theory, more methods, more technical data, more general education, and more human relations our present educational system leaves little time in which to encourage the develop-

*Awarded Honorable Mention in Young Engineering Teacher's Paper Contest, sponsored by ASEE.

ment of two of the most important attributes of an engineering mind—a natural curiosity, and the ability to reason. Without these two qualities, a graduate engineer will have difficulty in maturing in a professional sense.

From a positive standpoint, there is very little that can be done to develop natural curiosity. However, this natural curiosity can be greatly retarded or suppressed if a person, whether due to a lack of fundamental knowledge or the ability to apply this knowledge, continually fails to arrive at a satisfactory solution to the problems which his curiosity initiates. In order to keep actively curious, the mind must produce results based upon facts and the ability to reason. Assuming that the normal engineering graduate receives an adequate amount of knowledge in his college work, and judging from industry's overall appraisal this seems to be the case, then the challenge to our teaching methods is presented by this other requisite—the ability to reason.

An instructor should indicate to his students that he is attempting to develop their reasoning ability; it should be listed as one of the objectives of the course. As soon as the class commences to use its new-found material in solving unfamiliar problems, the instructor should emphasize the reasoning involved in the solutions and point out to the students the manner in which they are exercising their reasoning ability. The student must first develop self-confidence in his reasoning, if he is expected to expand in this direction.

Some students will argue, "I'm not so good at original thinking"; and they are no doubt telling the truth. But the application of known principles to a slightly different situation certainly does not come under the category of "original thinking." Certain facts, principles, and laws must be memorized in mastering subject matter. However, there is a tremendous gap between this learning by rote and true original thinking. It isn't at all limiting to say that the aim of instruction should be somewhere between these two extremes.

An instructor should not be overly ambitious in the amount of course work that he covers. Many engineering texts contain more material than can possibly be discussed in the time allotted for the subject. Each course should have a definite amount of fundamental material which represents the minimum that should be taught to the student. Beyond that point careful consideration should be given as to whether the time can be spent more profitably in teaching more methods, more short cuts, and more specialized data or in going deeper into the subject and attempting to develop thinking power along those lines.

Questioning Technique

The questioning technique in the majority of our engineering texts is not intended to encourage a great deal of reasoning. As a rule, the questions are listed at the end of each chapter, occasionally even subdivided as to section, so that a student in solving a problem looks up the example which seems to apply and follows through the method of solution. This is probably an exaggeration, but for the most part the standard textbook problems seem unsuited to the development of this reasoning ability. Unless there has been an error in publication, a problem is seldom printed which contains unnecessary or insufficient information. The problems are concisely stated using standard symbols, and with facts clearly stated. The majority of problems definitely should be presented in this manner, but the instructor should occasionally supplement this type of problem with one which involves some constructive thinking. In actual practice, the graduate will not find the facts listed in a, b, c order, with the method of solution suggested.

In analyzing an unfamiliar problem there are certain properties that a student should look for. The first thing to be determined is "What is the question?" This is necessary, since the pertinent data are frequently so cluttered up with superfluous material that the meaning of the

problem is doubtful. After the student has sifted through this unnecessary wordage and arrived at the meat of the problem, he should next ask himself if a solution is possible. Unfortunately, every problem does not have an answer, and a great deal of effort can be wasted in attempting a solution based on insufficient data.

In determining if a problem has a solution, the number of unknowns present, and the number of independent equations available should be considered. If the unknowns exceed the number of independent equations, an exact solution is unlikely, but the problem still may be worthwhile, from the engineering viewpoint, by either of two approaches: It may be possible on the basis of the data to set up definite limits between which the answer must fall, or by making an assumption, the problem may be solved for an approximate solution. A great deal of engineering work is done in this manner, and an early exposure to this method of procedure is worthwhile for the engineering student.

The student should learn to differentiate between facts, assumptions, and conventions. If he is working exclusively with facts that completely satisfy the conditions of the formula, then he is justified in working out the solution to a great degree of accuracy. Assumptions should be approached more carefully, however. They may be reasonably close or only a rough approximation, and the validity of the answer should be consistent with the quality of the governing data. The student should realize that he is introducing false accuracy into an answer, if he expresses the solution to four significant figures when one of the controlling variables was approximated to the closest ten per cent.

Similarly, in teaching sign conventions, such as a clockwise moment being positive, the instructor should emphasize to a student that conventions are not hard and fast rules, but are merely set up as a convenience to aid in the solution of problems. A student should develop respect for the facts, skepticism for the assumptions, and willingness to completely reverse the conventions if it suits his purpose.

Classroom Discussion

Every effort should be made to encourage classroom discussion, not only on the material of the instructor's choice, but on questions and problems originating from the students. A class will be more interested in problems of their own selection, and this will also give the instructor the opportunity to illustrate the thought processes he goes through in approaching an unfamiliar situation. Rather than attempting to impress the class with the ease and rapidity with which he can arrive at a solution, it will be more beneficial if the instructor takes time to orally evaluate the problem, to point out the reasons why he mentally rejects some possible solutions, and to explain why his chosen plan of attack seems the most reasonable. He may be called upon to defend this stand, if a student feels as though another method of solution is superior. This is a healthy condition, since any variance of opinion involves a certain amount of independent thinking on the part of the members involved.

It is possible to misplace the emphasis in attempting to develop a student's reasoning ability. If an instructor tells his class, "In order to reason through a problem of this nature, follow these four steps . . .," and proceeds to outline the steps, then all that he is teaching is another method, since there is no independent thinking required on the student's part. An instructor should not endeavor to have a class duplicate his thought processes, but have them develop analytical ability of their own.

Teaching by Example

An instructor should continually keep in mind that a great deal of the information and the attitudes that a class derives from his course are based as much on his example as on what is said. Recently, one of our professors, on entering emeri-

tus status, received a congratulatory letter from a former student who is now a successful engineer. In reviewing his college training, this former student related that one of the most worthwhile features of his college work had been the fine sense of ethics he had acquired in attending one of the professor's classes. "Ethics," snorted the professor, "I never even mentioned the word," and he probably hadn't.

There are other phases of instruction that are taught by example. The best method of increasing the technical vocabulary of a class is not to have them memorize a list of words, but to use the technical terms frequently in classroom discussion. Similarly, along the lines of general education, an instructor with a broad view of his work and a general appreciation of the world in which he lives, can have as great a liberalizing influence on the engineering student as some required course designed for this purpose. Therefore, in developing the reasoning ability of a class, the instructor, in his discussion and explanation of difficult material, should give some evidence of using the analytical approach, and build up the student's confidence in its possibilities.

The probable origin of the word "engineer" is the medieval Latin word "ingeniarius" which also fostered the words, engine and ingenuity. In training engineers, the instructor should concentrate on making the students more ingenious and less like engines, which are machines that go through repetitive motions. He should encourage in every way possible the development of a curiosity and a desire for self-improvement, so that the student will continue to grow, professionally and socially, upon graduation. The instructor should emphasize the analytical approach, for this approach is not unique with our engineering experiences. Judgment, based on a careful consideration of the facts involved, should govern the decisions in all phases of human endeavor.

College-Industry Conference

of the

Relations With Industry Division

will be held on

January 16, 1954 **University of Detroit**

Helping the Student Master the Art of Thinking*

By KIN NEE TONG

Assistant Professor of Mechanical Engineering, Syracuse University

After meeting a new class in recitation for a few times, an instructor in engineering sciences can usually sense which pupils in the class are going to do well in the subject and which ones are likely to fail. Although he is not willing to be opinionated by such first impressions, he cannot help feeling secretly that there is some intangible quality in the individuals of the class that separates them into different scholastic strata. This is indeed a most frustrating feeling. To accept the existence of such stratification is to admit the limitation in his possible accomplishment as a teacher. His role would then be restricted to the giving of information; his performance could be reflected only in the general level of class progress; and his work would benefit the individuals only according to their latent capabilities, and thereby help to perpetuate and intensify the process of stratification.

There is no sense in arguing that all individuals are mentally equal; nor in advocating that a class be escorted like a convoy, moving with the slowest ship. Nevertheless, it is doubtful that all the differences in the performance of individual students can be attributed to the differences in basic intelligence, in mental aptitude, or in whatever names are used by the numerous tests given to entering freshmen. Leaving personality problems to the psychological service, personal problems to the dean of men, and other academic problems to the private tutors, an instructor shall still find means whereby he can bring up the rear rank without slowing down the pace of the forerunners. A group of untutored beginners in golf will card vastly different scores on their first games. The club pro can usually narrow down the difference by a few group lessons. He can never make everyone play equally well or all play under par; but within certain limits, he can teach all of them to play decent games. Why, then could not a college instructor achieve similar results?

Great ideas require genius; important invention calls for creativeness; but good engineering needs only some fundamental knowledge and some original thinking. An undergraduate program in engineering contains very little subject matter beyond the comprehension of any qualified freshman. Its object is within the mental reach of virtually all. Engineering schools do not aim to turn out Edisons or Teslas or even the kind of men who could invent the zipper. Their aim is far more modest —something of the order of better mouse trap builders. The necessary genius and creativeness needed for building better mouse traps are, after all, more common. If granted that fundamental knowledge and original thinking are the mainspring of good engineering, one may proceed to examine their nature. All quarters more or less agree on the make-up of the basic knowledge required in various fields of engineering; and students in education and psychology have theories on how this knowledge can be best imparted. But opinion varies when it comes to the ques-

* Winner of Honorable Mention in the Young Engineering Teachers' Paper Contest sponsored by ASEE.

tion of what is the nature of the original thinking essential in the engineering profession.

Logic and Order

One often hears the extolling of so-called logical and well ordered thinking. To be sure, logic is the main binding force in the structure of all science; and orderliness is the essence of all engineering feats; but it must be realized that nice logic and neat order are usually only the end-product of a thinking process which in itself may be neither logical nor orderly. How many neat solutions and elegant proofs were first thought of in the way they are presented in the textbooks or by the instructors in class? In most of them many missteps were made before the final results were obtained in the so-called presentable forms. An instructor may use up pages to prepare his lecture on the solution of a certain problem, only to find afterwards that it can be solved in a more direct but unforseeable way. Steeped in the tradition of Euclid and dazzled by the beauty of Aristotelian logic, he presents to the class the finished product of his thought in a most impeccable manner. Repeated exposure to such exhibition of mental feat gradually leads the students to believe that this is the way a problem should be and usually is attacked: logical, well ordered, and straight to the answer. If they fail to do the same with a new problem, they cannot help feeling that they are either too dull, or do not know the subject well. Most give up before they are half through. A few exceptionally bright ones may actually develop uncanny ability by studying uncanny ways, and thus serve to intensify the general frustration of the rest.

In the evolution of physical sciences, it is now recognized that there exists an incongruent duality in the making of science and the make-up of science. The neat and orderly "Rules of Philosophy" formulated by Newton in his Principia have long given way to the opinion of Einstein—"There is no logical way to the discovery of elemental laws." The pursuit of science is more an art than a science and, as H. D. Smyth said, "The research man may often think and work like an artist, but he has to talk like a bookkeeper, in terms of facts, figures, and logical sequence of thought."

While a pure scientist, owing to his relationship with his fellow workers and with posterity, has to distill his triumphant insight into hard facts, cold figures and bare formulas, a teacher in applied science has a more personal relationship with his students than a mere walking textbook. Neat derivations, and concise solutions serve only to prove the results are right; they do not give any idea of how an average person may arrive at the right results. A teacher in sculpture does not merely show his finished work with most of the chisel marks removed. He is expected also to show how he used his chisel.

Process of Reasoning

Attacking an engineering problem involves aspects as artful as sculpture. It is an important duty of an instructor to reveal to his class his private process of reasoning. Owing to his experience in solving problems, his reasoning is perhaps more straightforward than what his students are capable of, but it is still a far cry from what appears customary on classroom blackboards. Admittedly, it is not wise for an instructor to flounder around in front of a class. Consideration of his dignity aside, it is a waste of time and a waste of students' attention. Nevertheless, rational steps, which a person without the benefit of clairvoyance are expected to take, should not be summarily omitted, just because they prove to be unnecessary afterwards.

This common habit of demonstrating only the most direct and economical approach is perhaps formed unintentionally. Lectures prepared down to every detail, experiments with all the kinks ironed out beforehand, and standard problems used year in and year out, all contribute to ob-

secure the side issues which are likely to trouble any one who encounters them for the first time. Perhaps lectures should be prepared only in outlines; experiments should be prearranged only to avoid dangers and damages; and problems should be worked out impromptu in class. For those who know the subject too well, for those whose stubborn conscience compels them to be ever-prepared, the kinks and twists in normal thinking process can always be premeditated; and for those having the false pride of always showing their best, teaching a new and more difficult course may be in order.

Of course, there is also a consideration of time involved. It is difficult enough to cover a course in the usual manner without much digression, but if one is convinced of the value in demonstrating the art of thinking as well as the fruit of thinking, one should, and can somehow find time to do so occasionally. In any event, it should be emphatically pointed out to the students that there are two facades in any piece of original work, a private one and a public one. The private one is a silent but important partner in any mental undertaking.

Nowadays analysis is the magic word, and logic is the sacred cow. Both are undeniably essential in original thinking, but by their very nature neither of them can originate ideas. One can analyze things only when things are there, and one can reason by logic only when there is something to reason from. Even in mathematics, where the analysis and logic are most powerful, solutions of problems and proofs of theroems often require as much artful maneuvering in algebra, as pure deductive logic. Take the following remarks from an excellent textbook on differential equations by R. P. Agnew: "It is often possible to solve complicated differential equations by making a sucession of changes of variables. A standard procedure is to *try* various and assorted changes of variable, making use only of those which appear to simplify the equation, but if the equation occurs in an important problem, one can spend odd hours, days, weeks, or years hunting for them. We shall not illustrate the process of trying assorted changes of variables which fail to simplify the equation, but we shall illustrate results obtained after finding useful changes of variable." Such remarks, so obvious to an experienced mathematician, can be really shocking to many students, who never suspected that: (1) Not all differential equations are solvable; (2) Simplifying changes of variable, if any, are obtained by trials; and (3) There are problems important enough for people to keep trying to solve them for years. Can such naïvety be blamed when all problems ever presented to them were solved by a single assortment of changes of variable found within one class period?

Intuitive Experimentation

Most problems in engineering are not as well formulated as ones in pure mathematics. An exact solution either does not exist or is not unique. The possibility of making different judicial assumptions, gives added leeway and added necessity of experimentation in the avenues of attack. There, analysis is a weapon, logic is the rule of operation, but intuitive experimentation is the source of ideas. Students are so often admonished when they try to guess at an answer, that they consider guessing a sin. Guessing is not sinful so long as logic is always there to call "foul" when a foul is actually committed.

The ability and resourcefulness in tinkering with problems accentuate the qualities of good students, and depreciate those of the poor. In many cases, proficiency of good students in this artful aspect of thinking is fostered by their activities outside of classrooms, such as solving puzzles, playing chess and hobbies in crafts. Custom is such that except in advanced design courses, most of the problems illustrated or assigned are chosen for their direct bearing on the principles being studied. They are good drills for learning the laws and the relationships of physical phenomena. However when examination comes, most instructors are tempted to

insert a trickly problem to separate the men from the boys, so to speak. The result is the common complaint of poor students that they have worked every problem in the book and yet failed the examinations. Tricky problems can of course be avoided in examinations as well as in daily work just to quiet the complainers, but why postpone the facts of life until it is too late to do anything? It seems to be more sensible to make trick problems part of the regular diet, not for the sake of their nutritious value but for the sake of drilling the digestive power. The policy of mass high school education in this country does not permit room for intensive mental drills found in its European counterpart. Room, however, should be allowed as soon as professional education begins, without resorting exclusively to problems typified by Cambridge tripos.

The Art of Thinking

Any attempt in improving students' art of thinking, would give the slower minds more of a chance, without hampering the brilliant ones. Being an art, it cannot be taught by any set of stereotyped rules. The peculiarities in the functioning of the instructor's own private mind, dictate the best method for him. Perhaps all that is needed is just to be himself and to show how he does this or would do that. At any rate, no one can learn entirely by observing the mistakes made by others. Students must be urged and encouraged to drill their own minds, to make their own mistakes, and to correct their own mistakes. Judging and appraising the student's performance only by the end product are not conducive to the development of a sound and diligent thinking habit. Effort should be a criterion in grading any piece of work. Students who failed to get an answer after some reasonable trial, deserve far more credit than those who could not take a single step. Only in this way can one induce them to think, hoping in the long run they will master the art of thinking through constant practice.

It is perhaps appropriate to conclude this paper by a historical note in education. The ancient method of teaching children to read in China was to force them to memorize verbatim great classical works written in a language having little resemblance to the spoken language of the day. The teacher never explained what the words meant. The theory was that some day after five, ten, or twenty years of this, revelation would come to the students and everything they had memorized would make sense. The theory worked in some cases, and great scholars were produced that way. To many others, however, revelation failed to come, and they lived to be well versed illiterates. There may be some faint parallelism between this extreme method of teaching and some aspects of the common modern practice.

Young Engineering Teachers' Paper Contest

RULES

Eligibility: Members of ASEE who are not over 35 years of age (their 36th birthday must not be before June 1, 1954).

Awards: First prize $200—Second prize $100.
Honorable mentions as determined by the Judging Committee.

Presentation of Awards: The awards are known as the "President's Awards." They will be presented to the recipients by the President of the Society at the Annual Banquet at the University of Illinois, June 17, 1954.

Subject: Papers should deal with some constructive phase of improvement of engineering education. Participants are encouraged to use their own judgment in selecting appropriate subject matter.
The following are suggestions of possible subjects:

1. Professional development of the Young Engineering Teacher.
2. How should the student be helped to learn to deal with situations that are new to him, on his own initiative and with well-ordered professional thinking?
3. To what extent should modern physics be included in the engineering curriculum and how should this be done?
4. What areas of physics, chemistry, mathematics and biology not now taught in engineering curricula are likely to be translated into significant engineering practice in the next 25 years and how should this influence present curricula?
5. To what extent and in what manner should undergraduate instruction acquaint the engineering student with the methods of research and with recent research developments in engineering and closely allied sciences.
6. What should be taught of the art of engineering as contrasted with its science?
7. What basic science, mathematics and communication principles and skills can best be taught by separate department staffs and what part by integration into engineering courses?
8. What can be done in college to prepare the young engineer to continue to learn after his formal education is ended?
9. How should non-major courses in engineering such as electrical engineering for non-electricals be planned as to content and method?

Length of Paper: Not to exceed 2500 words.

Submission of Entries: All entries should be submitted to the Chairman of the ASEE Section in which the member resides before March 1, 1954. Names and school affiliations of Section Chairmen are published each month on the page in the Journal of Engineering Education designated "Section Meetings." Papers submitted in the contest last year or in other contests are not eligible for this year's contest.

Judging: Each Section of ASEE will appoint a Judging Committee to select the best paper from the Section. This paper will be submitted to the ASEE Secretary before April 1, 1954.

The winning papers from the various ASEE Sections will be submitted to a Final Judging Committee for the final selection.

Here is an opportunity to gain national distinction. Good luck!

Engineering Education from Industry's Viewpoint—One Man's Impressions

By RICHARD H. LEACH

Assistant Professor of Social Sciences, Georgia Institute of Technology

I enjoyed a unique experience during the summer of 1952. As a Fellow of the Foundation for Economic Education, I spent six weeks with the management of one of the nation's largest industrial firms, where, among other things, I had a chance to look over the academic fence from the other side. What I learned from my vantage point I want to set down for the benefit of my colleagues in engineering education before it loses its urgency.

General Impressions

The strongest impression I carried away, while it may not be new, was at least heartening to feel again. That is how important graduates of engineering schools have become to the management of industry—and thus how important their education is to industry's successful operation. They run American business, by and large. The company men I talked to agreed that there will always be a certain number of management people who work up from the ranks of workers, without the benefits of formal education, and this is as it should be. They agreed too that there will be others who come to industrial leadership from the liberal arts, and I think no one will belittle the contributions of such men. But they all emphasized that engineers remain chiefly responsible for a healthy industrial system. Eight out of ten men hired for management jobs in my host company are the products of engineering schools, and this is a common ratio. Moreover, company recruiting is more often than not begun on engineering campuses—industry, in other words, comes to us first to fill its needs. It was a great boost to my morale to realize again that I as an engineering educator am in the center of things, that I help to build the builders, that neither I nor my students have a mean or uninspiring role to play in life.

Secondly, I was impressed by the sympathy with and interest in engineering education the average industry man demonstrates. It was immediately obvious in every conversation that industry men gratefully acknowledge the vital role technical schools play in the success of their enterprises and that they are more than willing to do whatever they can to help us accomplish our educational job better. There were five professors in my group last summer, and each company official we met went out of his way to meet our individual needs. Their very attitude made me all the more anxious to reciprocate in turn and to offer them the very best graduates I can possibly help train.

My third impression, to which I want to devote the rest of my remarks, was that, despite praise and sympathy therefor, engineering education is not in every respect all industry people would like it to be. I recorded a number of their suggestions for improvement and change, and all, I think, are worthy of serious consideration.

Need to Develop Coordinated Curricula

One often repeated suggestion was that engineering educators should strive to develop better coordination with industry in planning curricula, in order that course

offerings may be better kept in tune with industrial needs and problems. Let me give two cases in point. In the company I visited, there is a real need for metallurgists. Yet few engineering or technical schools stress the subject or are equipped to offer it. Here is a real industrial problem which we to date have not met in our curricula. On the other hand, schools all across the land have vied with each other in setting up courses in industrial management, until the possible turnout of industrial management majors far exceeds the number of junior management jobs open to graduates. In such an endeavor, we are wasting both our efforts and considerable student-power which might better be utilized elsewhere.

One solution suggested to such curricular mismanagement was the establishment of industrial advisory committees to help correlate industrial needs and school offerings. Another was that engineering schools be made parties to the findings of the periodic surveys most companies make of their manpower needs, so that curricula could be tailored to fit the actual projected industrial picture. It seems to me there is merit in both ideas.

Weakness of Educational Guidance

Another common sentiment in industry, with which I heartily agree, is that engineering schools do not excel in the guidance of students toward the most suitable course offerings. Not only are we careless in establishing the proper connections between college guidance officials and placement officers, but many of us who guide are not up-to-date in our knowledge either of the school's total course picture or of the industrial pattern in the world outside. We ought not let students flounder along to a major. We should guide them intelligently toward one that both fits their capabilities and propensities and offers them a relatively certain chance of finding professional usefulness. Nor should we continually guide toward management—basic industrial jobs are important too. We probably over-emphasize management, in fact, to the possible detriment of our curricular strength.

Perhaps because engineering schools have not made a brilliant record at guidance, or perhaps only to supplement their activities, many industrial concerns now do their own guiding. I heartily recommend such efforts. But the real guidance job remains the faculty's; we cannot evade responsibility for it. It appears from what I heard last summer that a serious evaluation of that job is in order on many of our campuses. It is a suggestion we might do well to honor.

Need for Contact between Teachers and Industry

Many company officials felt that another thing needed was more opportunity for contact between those who teach engineers and those who hire and use them. I agree with them that to be effective teachers, we need to know industry at first hand, to see its methods and techniques in operation. We need frequent immersion in an actual industrial environment. But at present few of us have opportunity to do so. Fortunately, the opportunities are increasing. The Foundation for Economic Education, under whose College-Business Exchange Program I was a Fellow last summer, has made it possible to date for 288 professors from 162 colleges to spend six fruitful weeks with 96 of America's leading business concerns, and more such school-factory interchanges are scheduled for this summer. Many individual companies have adopted the idea of inviting professors for short periods. For instance, United States Steel's Columbia-Geneva Division last year held a nine-day educational session for a limited number of college people on the West Coast. And attacks are being made on the problem by other organizations and by several schools themselves.

More needs to be done, however, for the number of educators reached so far is only a tiny proportion of those who man our technical institutions. And we should

work to make the thing a two-way street. The colleges should increasingly open their doors to men from industry, if not as teachers, as occasional lecturers; if not as lecturers, as visitors and advisers, so that technical education can become much more of a partnership between the parties concerned than it is at present. These are educational developments whose possibilities are only now being realized. They are, moreover, developments of which industry heartily approves, and we should not hesitate to make the most of them.

Need for Economics

I often had this question asked me as I moved from department to department in my host company: "Why don't engineering schools teach their students the elementary facts of economics?" It was usually followed by the charge that engineers are turned out by the hundreds without the faintest idea of the principles that make our economic system tick and without any background in business as a whole into which to fit their job and their company. More than on any other point, the industry people I talked to agreed that there is a general and great need for economic education in the men who come to industry from our campuses. And it is true that too few of our graduates have any grasp at all of practical economics, of how business operates, of the economic process from raw material to finished product. Too few have any idea of the whole industrial circle, what and who it involves, how great a variety of jobs and functions it entails. Nor are they sure what relationship they as engineers bear to the rest of the industrial family. This flaw in their education affects their understanding of the business they enter and of its relation to the rest of the nation and the world.

It is our job as educators to awaken to the situation and see to it that the engineering curriculum is made broad enough to include a course or courses in basic economics, required of all our students, if we would properly fulfill our obligation to them and to their employers, as well as to society as a whole.

Over-specialization

Closely related to the need for training in economics is the general problem of what the total amount of non-technical courses ought to be in the engineering curriculum. One of the most challenging ideas I encountered was presented by the director of industrial relations for one of the largest manufacturing companies in the United States, when he discussed the subject of over-specialization in engineering education. He admitted that his company, like others, wanted and hired men with technical specialties, but he deplored the fact that so many came to them with nothing else. His point was not that engineering schools need turn out anything but engineers, but that in turning out engineers, they ought to take pains to produce graduates with knowledge and understanding in fields other than engineering. He said that his company often felt that some of their neophyte employees might as well have come from trade schools as from accredited engineering schools, so deficient in any knowledge beyond their technical specialty were they. He did not for a minute deny that we produce fine engineers, specialists in things. But he felt that we send those specialists out into the business world completely unequipped in other, equally important, areas of knowledge. Companies want men who are more than one-sided, who have besides professional competence at least a knowledge and an understanding of the social aspects of life—the human factor, if you will. He expressed the firm conviction as he concluded that for present day business leadership, broader education of some sort was a necessary qualification, and he urged us to train our students more intensively along non-technical lines.

Representatives from five other industrial firms in the Pittsburgh area heard him make these remarks, and all of them hurrahed when he made his points. They

were unanimous in their opinion that so far engineering education is weak on the human side, a weakness that has become chronic through the years, a weakness all of us need to study seriously and seek to correct. So widespread has the feeling become that recruiting people from two or three of the firms in the Pittsburgh area have begun to hire fewer engineers and are turning instead to business administration or liberal arts graduates to fill their junior management positions. Why? Because with their broader education, they have been doing better jobs in management than those who are merely engineers. One company official said that his company would hire 100 out of 450 management candidates from non-technical schools during 1953, and that unless the engineers' training improved, that proportion would be increased. These are serious men talking about a serious problem. We need to take careful note of them. They but underline the importance of continually striving to improve our curricula, and they issue warning to those of us who hang back that we are but hurting ourselves.

Other Curricular Weaknesses

Two generally voiced complaints about engineering curricula are especially worth comment, it seems to me. One was that our curricula often contain much that is of no real value in industrial practice, that too much time is spent on "theoretical" aspects of engineering and too little time on practical training for industrial occupations, that we offer, in short, too few realistic and useful courses. Perhaps we should pay heed to that complaint, at least to the extent of applying a broom to the cobwebs in our curricular corners. The other complaint was that our curricula are weak in teaching students the art of self-expression. Neither in writing nor in speech do most of our graduates excel—I think we can admit it—and yet wherever they go in industry, they must necessarily write technical reports, if only for intra-office circulation, and address groups of people on engineering problems. No matter how well we do our job of training them in their specialties, they tend to lose their effectiveness on the job if they cannot clearly express their opinions and ideas. Company official after company official begged us to take back to our campuses the message that if we do nothing else, we should stress the art of self-expression in our teaching, even if in so doing we cut into the time we have traditionally given to engineering subjects.

Humility and Service

Finally, it was impressed upon me that we as educators should not forget that to a great extent in all aspects of industry it is still experience that makes the man. As we teach, we need not concern ourselves with training for perfection or for high executive position. Our function is a more limited one: to supply the solid foundations on which to build a career in industry. The career itself we must leave to each man, for only he will set the limits to his own eminence. But we can do something, nevertheless, to help him on his way up. In our classes, we can impress on him that he must not expect his engineering training alone, valuable though it will prove to be, to open all doors to success unassisted. We can instill in him the idea that to succeed in his job, he needs the basic knowledge we give him plus the will to work, to grow, to seek opportunity for service, and above all, to produce. Perhaps if we occasionally remind him that he will probably begin his industrial career with still more training, for perhaps as long as two years, during which time he will be of little use to his employer, we could emphasize the point! Such a reminder might serve also to remove a little of the "cockiness" that industry men all find so objectionable in our recent graduates.

In other words, we need to teach humility—to train in the ideal of service—to inculcate a self-propelling interest in work that will carry the student from the

lowest rung of the industrial ladder all the way up. We can boost him onto that first rung, but the rest he must negotiate for himself. If we can succeed in implanting this kind of approach to his job, if we can teach him that his successful future rests much more on himself than it does on what he learns from us, we will have met the obligations of our profession as we should. If, in addition, we strive to maintain the best curricula we can, as closely in line with industrial needs as possible, we can then be sure that we have done what we should in the cause of engineering education and American industrial strength as well.

Leading Hydraulic Engineers from Eighteen Countries Attend Minnesota International Hydraulics Convention

The Minnesota International Hydraulics Convention, which combined the fifth plenary meeting of the International Association for Hydraulic Research and the second separate meeting of the Hydraulics Division of the American Society of Civil Engineers, introduced several innovations in meetings of this character. It was held at the University of Minnesota in Minneapolis September 1–4, 1953, with many eminent scientists and engineers from eighteen countries throughout the world in attendance, as well as delegates from 35 states of the United States and the District of Columbia. Preceding the Convention by one day, there was also in session a Hydrology Meeting of the North Central Regional Branch of the American Geophysical Union.

A particularly unique feature of the Convention was the pre-publication of all technical papers in a monumental volume, elaborately illustrated by 550 diagrams, charts, and photographs, containing some 570 $8\frac{1}{2} \times 11$ size pages incorporating 49 comprehensive hydraulics papers by 75 authors from some 20 countries. The preprinting of the Technical Proceedings proved to be exceptionally effective in scheduling the technical sessions and stimulating discussion.

The theme of the Congress was directed toward four geophysical aspects of hydraulics as follows: (a) Basic Relationships of Sediment Transportation by Flowing Water; (b) Density Currents; (c) Air Entrainment by Flowing Water; and (d) Waves, Beach Erosion, and the Hydromechanics of Shore Structures. Countries participating for the first time since the World War in these sessions included Yugoslavia and Japan. A one-half day tour was made through the St. Anthony Falls Hydraulic Laboratory, displayed in full operation.

Training in Research*

By ROBERT L. PIGFORD

Professor and Chairman, Chemical Engineering Department, University of Delaware

The essential elements of "training for research" of the type used for education of students and for contribution to scientific progress seem to me to be:

(a) The existence of the right "atmosphere"
(b) Recognition of research accomplishments by students
(c) Proper definition of thesis objectives and occasional review of objectives.

The academic atmosphere will not be right for productive research unless the majority of the staff members is actively engaged in research as individuals. The atmosphere should be one in which there is frequent evidence of "ideas in the making," as J. H. Hildebrand describes the situation in a successful western university chemistry department.† If the staff is inclined to be excited about new things and about more thorough approaches to familiar principles the students are likely to follow. If the staff members are interested in each other's research work the students are likely to feel that they are members of a department-wide research family. There should be no intellectual autocracy. Each student should be taught to feel that he is entitled to question every result and conclusion of staff member and fellow student alike. Such criticism should be welcomed.

Research Seminar

The research seminar is an effective administrative device that can contribute to the proper atmosphere. If there is active interest of the whole staff in the thorough review of partly or totally completed research projects the students who present their plans, results, and interpretations will feel that they are making a worthwhile effort. The staff and students should participate in the discussions on an equal basis, the staff members behaving not as the students' judges but as their partners in a fascinating game. Occasionally, staff members should describe their own personal research to the seminar for criticism and comment by colleagues and students alike.

The success of such a seminar probably can be judged by the vigor of discussion or friendly argument that the presentation produces between members of the audience as well as between audience and speaker. Enough time should be devoted to each subject to give more than a superficial treatment of each problem; the intellectual interest often increases rapidly after more than an hour's discussion of a subject that may have been initially uninteresting.

Enthusiasm for Research

As in every field of creative endeavor, enthusiasm for research is greatest when those doing it experience recognition for work well done. There is probably no greater force driving a student to spend time at his laboratory bench or in his cubicle in the library than the expectation that his results will be acknowledged

* Presented at the Dartmouth Meeting of the American Society of Engineering Education, June, 1952.

† J. H. Hildebrand, "The Making of a Teacher," *Chem. and Eng. News*, **30**, 2072–5 (May, 1952).

eventually as being good and significant. Students who feel themselves to be "pairs of hands" are likely to behave as laboratory helpers without taking advantage of the unexpected observation and without reaching new conclusions different and better than the preliminary ones that have been handed down by their research advisors.

One essential element of a good graduate research project is intelligent initial planning. Students beginning their graduate study are too often convinced that a research program consists of collecting data from a certain piece of equipment operated at definite experimental conditions laid down according to a plan devised even before the equipment is constructed. Frequently it must be emphasized that the only suitable object for a graduate research program is the investigation of a physical principle or hypothesis. Usually the aim of a thesis can be expressed by asking a question, such as "Can thermodynamic free energies of ternary mixtures be predicted successfully from binary experimental data alone?", or "Is it possible to explain existing anomalous rates of gas absorption in liquids on the hypothesis of a resistance in the gas-liquid interface?" Such a question should be put to the student as early as possible; it may even be a good idea to ask him to write it down in his laboratory notebook along with an explanatory paragraph. He should be helped to realize that his assignment is to find an answer by whatever means, either experimental or theoretical, he and his advisor can jointly or separately devise.

On the other hand, most student theses require more assistance from a staff member than help with the definition of the problem. While theses reporting negative results are not necessarily bad the average student benefits much more from positive accomplishment. Usually it is unwise to suggest a problem to a student unless the advisor has done enough preliminary work on it by himself to be reasonably sure that acceptable and useful experimental and theoretical methods are available.

Academic research is fascinating work that requires some of the same qualifications for successful "direction" as does good class room teaching. The instructor who has the patience and sense of humor required to become a real colleague of his thesis advises is likely also to be one who senses the problems of his students in formal classes and who is remembered as a teacher who added something to the textbook.

A Forecast of Engineering Freshmen and Graduates During This Decade

By NORMAN N. BARISH

Associate Professor of Management Engineering and Secretary of the College of Engineering, New York University

What are the prospects of undergraduate enrollment during the rest of this decade? How many freshmen can engineering colleges expect? How many engineering graduates will be available to help meet industrial and military requirements? To help answer these questions, a series of statistical and graphic analyses were undertaken.

Relationship between Births and Male High School Graduates in the United States

Chart 1 [1] shows the relationship between male and female births and male high school graduates eighteen years later. The chart shows a steadily increasing per cent of persons graduating from high school. From 1928 through 1940 the per cent has more than doubled (from 9.6 per cent to 20.1 per cent). The war years caused a temporary reversal of this trend, but the trend of increased per cents of high school graduates has continued in recent years.

Only male high school graduates are used because the proportion of females entering engineering colleges is so small as to have no significant effect on total enrollment. The ratio of the two sexes at birth has been very stable from year to year at a level of about 1055 males per 1000 females.[2] There is, thus, no loss of accuracy in comparing male high school graduates with total number of male and female births. The only effect of using male and female births instead of male births is that the per cent of high school graduates to births eighteen years earlier is reduced by a fixed ratio (0.487).

Births are plotted on this chart to 1941. Using this birth data we would like to forecast the number of male high school graduates to 1959. A least squares trend line was computed using the percentages of male high school graduates to births eighteen years earlier from 1928 through 1951. This is indicated on the chart by the lower trend line. Forecasts were then made of the number of high school graduates from 1952 through 1959 by multiplying the extrapolated trend percentages by the number of births eighteen years earlier. These forecasts of high school graduates are indicated on the chart by the lower dashed extension line.

The deep trough which occurred during the war years in the number of high school graduates undoubtedly causes a somewhat downward bias in the least squares trend line just computed. To attempt to correct for this bias, an adjusted least squares line was computed, omitting the unusu-

[1] The number of births, male and female, is based on publications of the National Office of Vital Statistics. The number of male high school graduates was obtained from the Biennial Survey of Education. For the last three years (1949 through 1951) the number of high school graduates was based on Office of Education estimates published in *School Life*, 1951.

[2] Statistical Bulletin, Metropolitan Life Insurance Company, Vol. 33, No. 8, Aug. 1952.

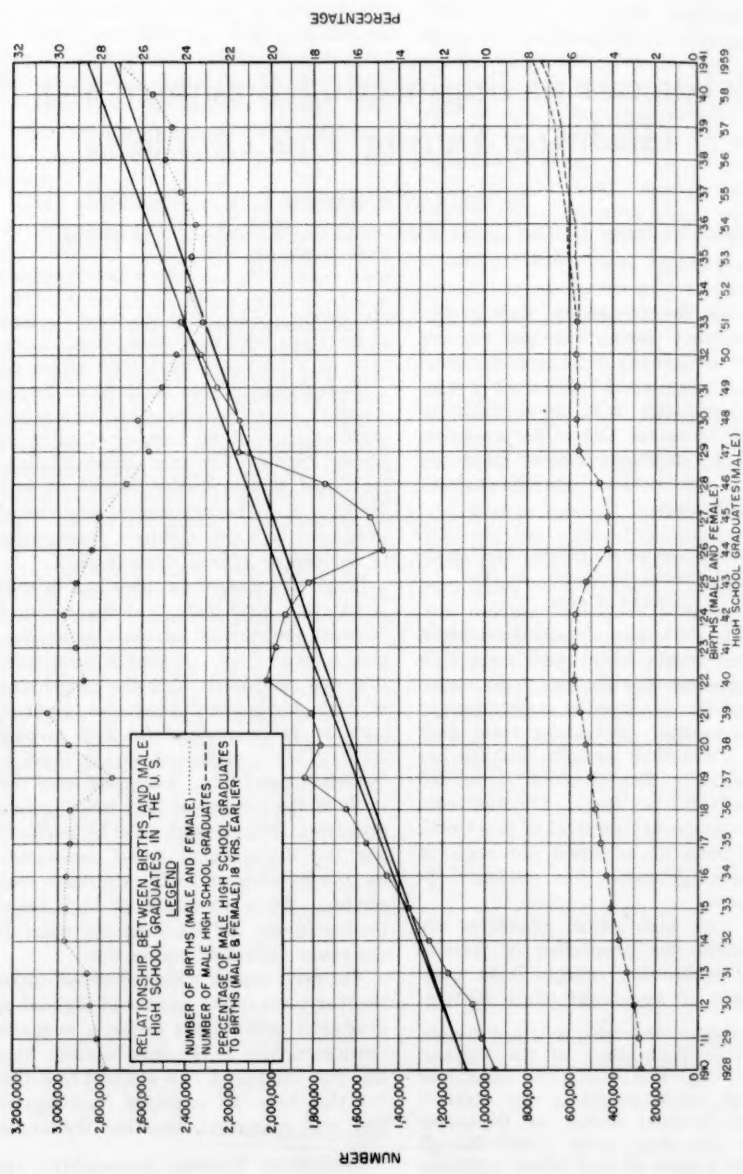
RELATIONSHIP BETWEEN BIRTHS AND MALE HIGH SCHOOL GRADUATES IN THE U.S.
LEGEND
NUMBER OF BIRTHS (MALE AND FEMALE)
NUMBER OF MALE HIGH SCHOOL GRADUATES
PERCENTAGE OF MALE HIGH SCHOOL GRADUATES TO BIRTHS (MALE & FEMALE) 18 YRS. EARLIER
NUMBER
PERCENTAGE
BIRTHS (MALE AND FEMALE)
HIGH SCHOOL GRADUATES (MALE)

CHART 1.

ally low percentages caused by the small high school graduating classes of 1944 and 1945. To be on the conservative side, the percentage for 1946 was included in the calculation even though its low value was undoubtedly caused to a great extent by the war. This adjusted line is indicated on the chart by the upper trend line. An adjusted forecast of the number of high school graduates based on this adjusted trend is indicated on the chart by the upper dashed extension line.

The forecasted number of male high school graduates based on each of these trend lines is indicated in the table below:

Year	Unadjusted Forecast	Adjusted Forecast
1952	565,500	588,900
1953	578,400	602,800
1954	580,700	605,900
1955	607,800	634,600
1956	642,000	670,900
1957	647,300	676,900
1958	685,000	716,800
1959	740,100	775,000

These forecasts indicate that high school graduations can be expected to surpass considerably all previous peaks in the very near future.

Proportion of Male High School Graduates Entering Engineering Colleges

Chart 2 [3] shows an increasing proportion of male high school graduates entering engineering colleges throughout the 30's and early 40's until the draft made serious inroads. The high per cent in 1930–31 of high school graduates entering engineering college might be explained by the lack of employment opportunities for high school graduates caused by the beginning of the Great Depression. The trough of the decline in the percentages from the post-war peak of 1946–47 caused by the veteran bulge was reached in 1950–51.

A least squares trend line was computed using the percentages of previous year high school graduates entering engineering colleges from 1935–36 through 1951–52. This is indicated on the chart by the upper trend line.

This trend line is undoubtedly biased upward by the extraordinarily high percentages caused by the large number of returning servicemen entering engineering colleges in the falls of 1946 and 1947. To attempt to correct for this bias, an adjusted least squares line was computed omitting the unusually high percentages for the years 1946–47 and 1947–48. This adjusted line is indicated on the chart by the lower trend line.

To obtain trend estimates of the number of engineering college freshmen, we multiply the extrapolated trend percentages for 1952 through 1959 by the previously forecasted numbers of male high school graduates. Two sets of trend values are obtained: (1) unadjusted trend values by multiplying the unadjusted estimates of the high school graduates with the unadjusted percentages entering engineering colleges; (2) adjusted trend values by multiplying the adjusted estimates of high school graduates by the adjusted percentages entering engineering colleges. The unadjusted trend values for the number of engineering college freshmen are shown by the upper dashed extension line and the adjusted trend values by the lower dashed extension line.

Forecast of Engineering College Freshmen

The forecasted number of engineering college freshmen based on each of these

[3] The number of male high school graduates was derived as explained under Chart 1. The number of engineering college freshmen was obtained from the journals of the ASEE. Data for omitted years was either unavailable or incomplete. From 1949 onward, enrollment data is restricted to E.C.P.D. accredited institutions. However, the institutions included in years previous to 1949 were almost entirely E.C.P.D. accredited institutions. Thus, this change caused an approximate 4 per cent reduction in the 1949 undergraduate enrollment figures as compared with what it would have been if no change had been made in the lists of institutions.

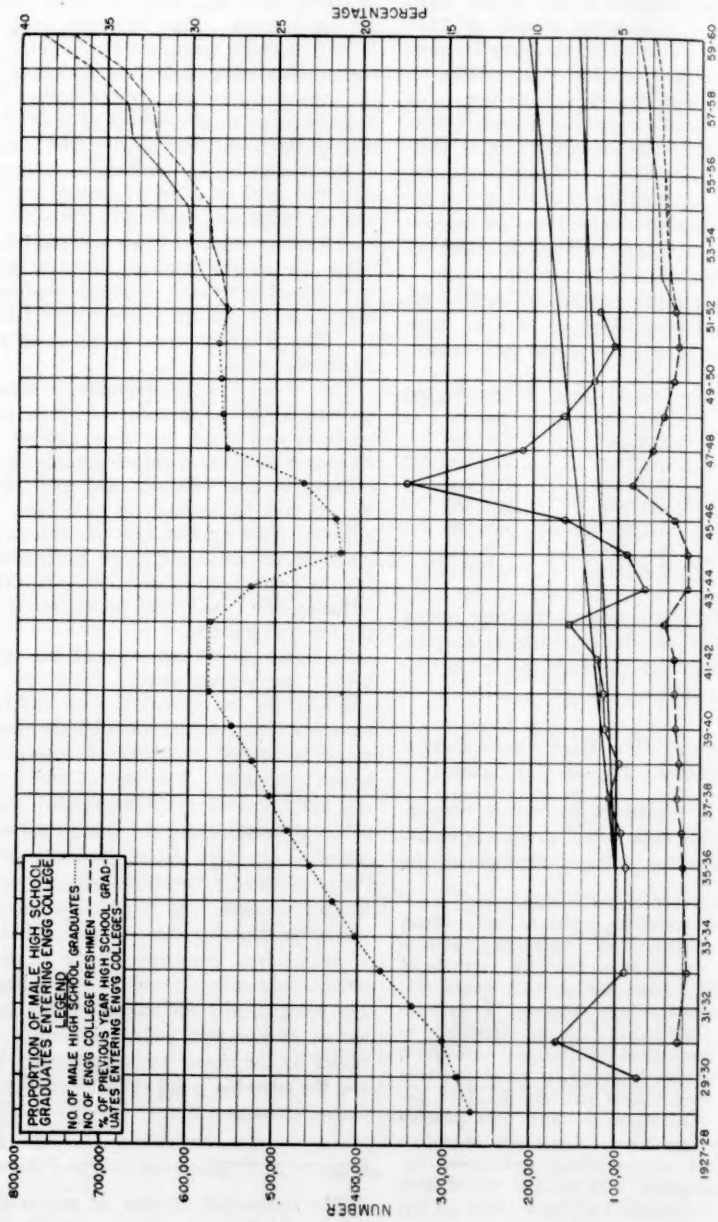
PROPORTION OF MALE HIGH SCHOOL GRADUATES ENTERING ENGG COLLEGE
LEGEND
NO. OF MALE HIGH SCHOOL GRADUATES
NO OF ENGG COLLEGE FRESHMEN
% OF PREVIOUS YEAR HIGH SCHOOL GRADUATES ENTERING ENG'G COLLEGES
NUMBER
PERCENTAGE
YEAR
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
40
35
30
25
20
15
10
5
1927-28
29-30
31-32
33-34
35-36
37-38
39-40
41-42
43-44
45-46
47-48
49-50
51-52
53-54
55-56
57-58
59-60

CHART 2.

trend lines is indicated in the following table:

Year	Unadjusted Forecast	Adjusted Forecast
1952*	49,800	39,900
1953	52,300	41,500
1954	53,800	42,300
1955	57,700	44,900
1956	62,400	48,200
1957	64,400	49,300
1958	69,700	52,000
1959	77,000	58,100

* These forecasts were prepared before the 1952 enrollment figures were available. Actual Engineering enrollment of 45,854 freshmen in 1952 turned out to be just about midway between these estimates.

This approach gives higher results than the commonly accepted analyses. The basic reason for the differences is that the commonly accepted methods usually imply that the same per cent of the age population will graduate from high school as at present or that even though this per cent may change, the proportion of those graduating who will be fit to choose engineering study will vary inversely with the change in the proportion of the age population graduating.

The method of Chart 2 is based on an extrapolation of the trend towards increased percentage of the age population graduating from high school as well as an increased percentage of those graduating attending engineering college. Displacement of the extrapolated trends gives a high and low range to the estimates on the chart. These forecasts, of course, have quite a number of limitations: they assume that basic trends of the past will continue into the future; being long term trend values, these forecasts do not account for many of the year to year variations; and any radical changes in the draft, manpower, and economic situations can easily upset these trends.

It is important to realize that extension of the trend line towards higher percentages of high school graduates entering engineering colleges cannot be expected to continue indefinitely. The proportion of students who have the intelligence level to be successful in engineering, the sciences, medicine, and other professions is rather fixed. Increases in the number choosing engineering must naturally impinge on the number available to choose the other professions. However, with increases in the proportion of persons graduating from high school, a larger reservoir of qualified manpower is available for professional training.

Student Attrition in National Undergraduate Engineering Enrollment

Between 75 and 95 per cent of our freshmen become sophomores, with a typical figure somewhere around 75 to 80 per cent. Between 60 and 75 per cent of our freshmen become juniors, with a typical figure somewhere around 60 to 70 per cent. Between 50 to 70 per cent of our freshmen become seniors, with a typical figure around 60 to 65 per cent.[4] The average per cent of first degree graduates as a proportion of entering freshman class was about 50 per cent in the 1930's. In the post-World War II years this percentage has risen to about 60 per cent of the entering freshman class.[5] The effects of the veterans returning with advanced standing and the greater maturity

[4] The effects of students dropping out for a year or more and then returning and of arts and science and business majors transferring into engineering schools with advanced standing, are not compensated for in these figures. A strict interpretation of these figures will, therefore, not permit the conclusion that they represent the probability of successfully completing courses of study in engineering colleges. The true probability is undoubtedly lower than these figures indicate.

[5] The figures for first degree graduates as a per cent of the entering freshman class ignores the effect of evening programs which graduate some students. This was necessary because the enrollment data does not show a breakdown of evening students by class or distinguish between the degrees received by day and evening students. Thus, to the extent that evening students have graduated, they exert a slight upward bias on these per cents.

of the returning veterans are undoubtedly partially responsible for the higher percentages graduating in these early post-World War II years.

Some attrition of engineering students is doubtless inevitable. A certain amount of attrition is desirable in order to maintain adequate standards. It is not possible to say whether the present attrition is too high without detailed study of the causes of this attrition. Certainly that part of the attrition which might be due to economic difficulties of the student represents an undersirable dilution of our manpower resources. (Some of the marked variations in attrition rates in the past 30 years are undoubtedly due to the sharply varying economic conditions and employment opportunities prevalent during the past several decades.) Any attrition which is caused by failure of the engineering colleges to motivate adequately the student is an undesirable occurrence. The responsibility for any such attrition, of course, rests squarely on the engineering colleges. Some attrition might also be due to inadequate admissions' screening procedures. A detailed study of the causes of attrition in engineering schools might yield valuable information as to the important causes of this attrition as well as provide the basis for an intelligent approach to this problem.

Forecast of Engineering Graduates

The importance of the attrition rate in determining the supply of engineering graduates in the future may be easily visualized by the table below which forecasts engineering graduates for the next ten years. The forecasts are made first on the basis of the pre-war attrition rates of approximately 50 per cent of the freshman class graduating. Then, a calculation is made using the post-World War II rate of approximately 60 per cent of the freshman class graduating four years after admission. Both forecasts are made on the basis of the analysis described in connection with Chart 2.

Forecast of Engineering Graduates Based on Adjusted Freshman Forecast in Chart 2

Year	50% of Freshman Basis	60% of Freshman Basis
1956	19,900	23,900
1957	20,700	24,900
1958	21,100	25,400
1959	22,500	26,000
1960	24,100	28,900
1961	24,600	29,600
1962	26,500	31,800
1963	29,000	34,800

Thus, the long term outlook for the supply of students for engineering education and the supply of graduate engineering talent to industry and government is not as bleak as some commonly accepted forecasts indicate. The engineering schools will have to gird themselves and prepare to meet this challenge for effective expansion of their programs. Industry and government will also need to make plans at the same time to absorb effectively this prospective larger number of graduating engineers.

The over-all growth of engineering enrollments at the undergraduate level during the past three decades has been very modest. Compared with the rate of growth of our industry and technology, this rate of growth may not be adequate for the long pull. No attempt has been made in this paper to gauge the demand for engineers. This demand varies widely with changes in the defense program and with economic conditions. Surveys frequently exaggerate the demand because employers in a tight labor market are apt to try to overhire to take into account prospective staff losses as well as the fact that they are never able to attain their full quota of the graduates for whom they apply. Labor pirating, of course, promotes this condition. Whether industry will have sufficient engineering manpower in the near future will depend to a great extent on the proportion of the graduating class which will be taken by the armed forces. Those graduating engineers who are inducted will not be available to industry until their discharge

several years later. Thus, short term availability of new graduates may be postponed by the armed forces manpower policies.

Engineering schools, industry, and government can cooperate in meeting the challenge created by the current shortage of engineering skills and promote the resolution of this manpower bottleneck. The establishment of sound policies for the utilization of existing engineering and technical skills in the most effective manner will help compensate for the shortages during the current period. The interest of American youth in engineering can be encouraged by public relations programs which explain the nature of the engineering professions and emphasize the leading roles they play in our society. Students whose natural abilities will enable them to be most successful in engineering study can be further encouraged to choose an engineering career by arranging for closer engineering college collaboration with the high schools. If the highly qualified high school graduates required in the engineering profession are to be encouraged to enroll in engineering schools, consideration should be given to the practicality of establishing long range employment plans which will allow enough variability to absorb the fluctuating number of engineering graduates which will be thrown on the employment market each June. Part of the drop in the proportion of college freshmen entering engineering colleges in some of the recent years has undoubtedly been due to the employment difficulties of some of our peak post-war pre-Korean graduating classes. This poor employment situation in individual years can repeat itself and do much to discourage qualified high school graduates from enrolling in engineering schools.

Sections and Branches

The **National Capital Area Section** of the ASEE held its Fall Meeting October 3, 1953 at the Johns Hopkins University, Baltimore, Maryland. Chairman Walther introduced Dr. Ralph Morgen and Mr. H. H. Armsby, the Section's representative on General Council, who reported on the 1953 Annual Meeting held at Gainesville, Florida June 1953. After various other announcements of coming section activities, the main part of the meeting was turned over to presentation of papers on the *Evaluation Programs* at various local engineering schools by the following:

1. *Howard University*—Professor Lee J. Purnell, Chairman of Educational Committee.
2. *George Washington University*—Professor John Kaye, Committee on Education.
3. *The Johns Hopkins University*—Professor H. E. Hoelscher, Committee on Education.
4. *The Johns Hopkins University*—Dean Robert H. Ray.

Professor Purnell said his committee took the philosophical approach, and came to the conclusion that more engineering students are needed and we must concentrate on this. Professor Kaye outlined his talk as follows: Objectives (Knowledge and understanding); Resources (curriculum, physical facilities, faculty, extra-curricular activities, methods of instruction); Achievements (evaluation of characteristics of students); and Recommendations. Professor Hoelscher talked about the Hopkins Program which is split into two curriculums—the operational or applied level (four years) and the Research or Theoretical Level (five years). Dean Ray spoke about the psychological and administrative problems of the Hopkins Program, giving advantages and disadvantages.

Types of Graduate Subsidy and Their Relation to Educational Values*

By ERNST WEBER

Professor and Head, Electrical Engineering; Director, Microwave Research Institute, Polytechnic Institute of Brooklyn

Graduate study in engineering has grown within the last 20 years from a few isolated centers to a scale which requires very careful reflection about its objectives and support. We all agree that graduate work is by far the most expensive part of a comprehensive program of engineering education and we appreciate that it cannot tolerate compromise with educational standards without loosing at once a great deal of its value.

However, all phases of human activity and endeavor are influenced by the socio-political atmosphere of the time. Surely, the very marked changes in social sensibilities in our life time have had some effect upon our concepts of education and our definition of educational values. Though, I am sure, we all realize these developments, I should like to review them briefly with some overemphasis in order to drive home the main point of my thesis.

The Social Reorientation

In these last 20 years we as a nation have turned from the social concept of "rugged individualism" to an objective occasionally defined as the "social welfare state." To be sure, differences of opinion as to degree still exist, but no political party in power can dare to undo the major changes in concepts of social obligation; indeed, many of these have become natural components of our attitudes.

Closely linked with this development is the change in concept of support of our higher educational system: from much endowment by few people to few institutions to a little support by all the people to all institutions! Implied is the conviction that agencies, whether federal or state, can distribute tax collections equitably and wisely. It satisfies social feelings to substitute group action for individual "arbitrary" decision.

But, in turn, it must now be required to give complete objective details concerning disposition of funds, because the responsibility is to a group of changing composition even though of fixed designation, rather than to an individual benefactor. Accounting procedures must be refined and made impersonal, extensive reports must be submitted, in short, patient paper work takes dominance over colorful individual demonstration of ability.

Finally, we need to recognize the psychological adjustment of the individual in this changing social pattern. Imperceptibly at any one time but inexorably nevertheless, the privilege of opportunity frequently becomes confused with an expected award and might even change in the individual's mind to a rightful demand.

Obviously, social change in itself is a healthy demonstration of the dynamic state of a nation. Like any dynamic process, however, it is more often than not of an oscillatory character and can carry beyond the appropriate momentary stable

* Presented at the Annual Meeting of ASEE, University of Florida, June 24, 1953 before the Division of Graduate Studies.

state. This must then stimulate certain reconsiderations.

Effect on Faculty Research

I am sure, we all agree that graduate study is inseparable from research. It is just unthinkable to have any worthwhile graduate program without strong faculty members interested in research and active in it. Thus, support of graduate work means essentially support of research. But this is precisely where the social reorientation has had its most profound effect.

Whereas it had been recognized that individually qualified graduate teachers should have their own laboratory facilities to carry on significant research and gather interested and qualified students as a small "school" around them—most institutions are now lacking the financial resources to support such programs as a matter of practical policy. Even the largest institutions in the country cannot afford the expensive research tools for the really fundamental research.

To the greatest part we have substituted sponsored research in programs of varying magnitudes but with stress upon team work and in many instances with closely defined objectives. Again, with full realization of the possibilities as well as the dangers, sponsored research must be accepted as the only presently available solution of an embarrassing dilemma: having stimulated graduate work to a point where it defines the prestige of an institution, we lack the means to carry through!

But we need to fully appreciate that the minimum sacrifice is a limited choice for the individual faculty member—unless he can associate with a project for which support is available, his chances for personal research are slim; and that the maximum danger is laboratory "employment" on research and development very much like in industrial laboratories with no personal choice of topic except as the recognized ability dictates.

Clearly, institutions should attempt to engage in sponsored research projects that contribute to the professional growth of their faculty and should be weary of carrying development programs merely to supplement faculty salaries.

Effect on Student Programs

The psychological effects of the social reorientation have been noticed in student attitudes. Whereas 15 and 20 years ago the student made a very weighty decision when he embarked upon graduate work and frequently anticipated years of struggle for a living and hard learning under the tutelage of a well-known contributor to research, he is now apt to stipulate how much time he might be able to spend on a degree program. To be sure, the general shortage of engineers, twice upon us within 10 years, has aggravated this situation. But it is not uncommon that a student might feel we owe him a degree and that he might take the demand for personal extraordinary effort as almost an imposition.

Because the sponsored research program can provide full employment together with the opportunity to carry forth graduate programs, students might select a line of least effort and maximum return —with the grave danger to consider as dissertation a well-written report on an assigned phase of a development program. But any good engineer would normally be expected to perform equally well just for his salary. It is up to us to realize the limits to which sponsored research can support the graduate research program without impairment of educational values and to jealousy guard the standards of achievement set for the advanced degrees. To a slight extent, I feel, we have already compromised in many places with respect to the requirements of a strong Master's program because of the increased number of students induced to take up graduate study either because it has been made a requirement for a position, or because of the larger reward in industry. Let us be sure to hold fast at least to the high standards of the doctoral programs.

However much we might deplore today the "rugged individualism," we must attempt to recognize in the advanced graduate student his best abilities, cultivate these and have them unfold to best advantage if we want to train leaders of tomorrow. However much we might exalt team work in research, we must attempt to spurn each member to his greatest efforts and give him the possibility of individual achievement. This requires diversification of a strong faculty, keen interest of faculty members in student progress, and an atmosphere of continuous alertness and growth.

Types of Support of Graduate Study

With this background it is almost self evident how I shall classify the various types of support of graduate study and research with respect to their relation to educational values.

Individual Faculty Research, supported from endowment, from research grants, from special gifts, with no specification of either topic or objective, should rank highest. Of course, this places the burden of award upon the department head or the dean, but it guarantees the maximum of flexibility for the best faculty members if the proper choice is made. Unfortunately, only a very small part of graduate research can be supported in this way because of the lack of appropriate funds.

Broad Research Fellowships rank next, and should in fact, be one of the strongest supports of graduate work. The student receives an amount adequate to sustain himself fully or partly, the institute receives an amount sufficient to cover tuition as well as research equipment and materials and preferably a contribution towards faculty research associated with the student's program. A broad topic is chosen by the student and eventually focussed by the faculty adviser. The Coffin fellowships of the General Electric Company, the DuPont and Westinghouse fellowships, as well as those administered by the National Research Council are excellent examples, but there are far too few of these at the present time.

Area Research Fellowships and Research Programs are quite similar to the previous group except that the area in which research should be done is specified. Excellent examples are the programs of the National Science Foundation and of the Office of Naval Research. In both instances, a proposal must be made by an institution stating broad objectives of the research and approximate scope of operation. Fellowships can be made part of the proposal, partial faculty services are included, and materials and supplies are covered. Since no restrictions are placed on publications of results, the educational value is still excellent; the only difficulty is the fact that concrete proposals must be made so that flexibility is wanting. A certain amount of accounting for the expenditures—less for National Science Foundation and more for the Office of Naval Research—is required. Similar fellowships are available from a few industrial companies.

Specific Research Fellowships are made available by certain industries for the exploration of rather specific topics, for the accumulation of specified data, for development of specific measurements or instruments. These fellowships can have educational value if carefully administered by a faculty member versed in the field. There are obvious difficulties of unsuccessful termination, of withholding publication because of patent interests, etc. which often militate against this type of research support.

Sponsored Research Projects represent today the largest single type of support of research in Universities and Colleges. If these projects permit the use of graduate students, place no restriction upon publications of the results, and provide challenging topics for the faculty they can materially assist in broadening the scope of graduate work and contributing to the professional growth of the faculty. If, however, the research program emphasizes development work with immediate

design objectives, considerable care must be exercised to avoid accepting the fulfillment of contract objectives as synonymous with proper objectives of graduate study. This will be particularly pertinent for classified military developments.

Research Centers and Research Institutes can be very valuable for the direct support of graduate work if and only if the leading research staff is closely integrated with the teaching faculty of the institution. Entirely separate organizations frequently develop their own policies and might not enhance the caliber and scope of graduate work.

Conclusion

The social reorientation in this country during the last 20 years has changed the concept of support of education and has brought about a change of attitudes and practices which might lead to ready acceptance of support of graduate work in engineering that actually has low educational value. I have attempted to review, in admittedly stronger terms than objectively justifiable, why these changes are potentially dangerous to the maintenance of high standards of graduate study and research.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Progress in the Humanistic-Social Division*

By STUART W. CHAPMAN

Executive Officer, Humanistic-Social Studies Department, College of Engineering, University of Washington

If we have been bedeviled at times by the epithet under which we work or have laughed at the academic double-takes which have followed its use, let us neither regret nor be too amused. In a real sense the seed of our Division, upon whose progress I report today, came into existence when the famous Hammond Committee in its 1940 report coined the term "humanistic-social" to describe one of the stems of the ideal engineering college curriculum.

History

The seed was sufficiently fertile to produce an embryo organization in September, 1944, when President Harry Rogers of the Society for the Promotion of Engineering Education appointed an Executive Committee of eight men for a new Humanistic-Social Division. But in this case the war retarded a birth. While delivery of a normal, fully-formed, nine-month baby was scheduled for the annual convention in June, 1945, in fact, because of government travel regulations, only labor pains occurred. These took the form of the publication of a series of papers which had been intended for meetings of a new Humanistic-Social Division at St. Louis. Thus the expected birth did not finally occur until the Annual Convention of 1946. At the ceremony thirty-one men assisted, of whom twenty-six were engineers.

Our gestation period was thus rather long. Between the gleam in the eyes of the men on the Hammond Committee and the final event, six years passed. But the heritage was good; now, seven years later, the Division has passed adolescence and has reached the first stages of maturity.

To prove this assertion let me state (1) that the Division has grown physically and in independence, and (2) has carried on a program which has contributed significantly to our thinking about problems of engineering education.

Look at our membership. In 1946 it consisted of thirty-one men. In the last Directory of the Society, eighty-two names are listed under Humanistic-Social, while under the English Division are the names of fifty or sixty others whose fields or whose own specification show their association with us in fact or in spirit. We have grown all right, but we have also grown independent. Of our original thirty-one members only five at the most were non-engineers. Of our presently-listed eighty-two members, sixty-three are from non-technical fields. Furthermore, as one looks at the record, he is impressed with the degree to which we were once dependent upon our technical colleagues. They fathered us; they constituted the bulk of the earliest nominating committees; they sometimes provided as many as half our speakers. In later years we have been getting along pretty much on our own. The Division is now self-operating, self-governing, and self-motivating. Participation of engineers in its organizational functioning and in its meetings has declined proportionately. (N. B. This statement is a record and not a boast.) We have not left our home in the ASEE

* A paper delivered at a meeting of the Humanistic-Social Division, ASEE, in Gainesville, Florida, June 24, 1953.

but our decisions, whether good or bad, have come to be more and more our own.

Significant Development

And to show for it, we have something of which we need not be ashamed. The Division has carried on a program which has been significant in the development of non-technical education for engineering students.

Only partly in jest I say that the program of the Humanistic-Social Division at these annual conventions has afforded many a man an opportunity to place upon his record the giving of a paper or participation in the activities of a professional society. If this has meant a promotion for this man or greater job-security for that, it is not an inconsequential achievement.

But, of course, of far greater moment is the contribution thus made to those who have spoken and to those who have listened. Many a person, when faced with a paper at one of our meetings, has been forced to crystallize, clarify, and evaluate his educational philosophy, his approach to a particular course, or his conduct of a special activity far earlier and more effectively than he would otherwise have done. The rest of us have been the beneficiaries of this thought.

Here I speak not at all in jest. We all have often said that meetings of professional societies are nice to go to because of the people you see and because of the conversations you have outside of the meetings. Papers? Oh, yes, they provide an excuse for the convention. As regards the sessions of our Division I can agree on the first two points. The people and the non-curricular conversations are most satisfying. But so are the papers. Every convention I have attended so far has given me a lift; I have come away feeling encouraged. Believe it or not, the papers, because of their thoughtfulness, sincerity, and practical concern with the problems of teaching, have given much of that lift. And I know that I am far from being alone in this reaction.

The record of our achievement as a Division is to be found largely in our annual meetings. As a full-fledged division of the ASEE we are now holding our eighth session in connection with an annual convention. We have also enjoyed two summer schools of three days each, one at Seattle in 1950 and one at East Lansing in 1951. At these meetings the bulk of our work has been done.

A listing of the subjects of the papers given is interesting. A rough classification, which is complicated by the crossing of departmental lines and by non-descriptive titles, gives the following results.

General philosophy of HSS programs	10
Discussion of HSS requirements or descriptions of programs	9
Methods of program planning	6
Teaching of values	5
Human relations	5
Art	4
Literature	4
Social science (general)	4
History	3
Science	3
Extra-curricular activities	2
Psychology	1
Ethics	1
Personal integration of instructor	1

What we should conclude from this summary I leave to you. Perhaps another program committee will find some suggestions here. As I look at the list, I suspect at least that we could afford to talk about our instructors somewhat oftener than two percent of the time.

Publication of some papers from our meetings is certainly a desirable follow-up. While I have not made a complete check-up, my impression is that the JOURNAL OF ENGINEERING EDUCATION is tending to publish fewer than it used to. In some years as many as five have been printed there. This year I believe the record is one. Perhaps five was more than we had any right to expect, considering the number of divisions in the Society; I am sure that one is too few to maintain the desired interest in the work of the Division

among our own members *and* our engineering colleagues.

For this reason the recent publication under separate cover of selected papers from two annual meetings of the Division stands out as an important achievement. To John Shirley, to Thomas Farrell—and the State University of Iowa—and to what others I do not know—should go our thanks. This work certainly deserves continuation in the years ahead.

Evaluation

This bare statement of facts will refresh our minds regarding the history of the Division. But I am supposed to speak about "past progress." Such a topic requires some evaluation and evaluation requires a set of standards. How well have we done?

The Past

In order to obtain criteria, let's look at some of the aims of the Division as they were early stated, especially by our first real chairman, Director Edwin S. Burdell of the Cooper Union. From these statements we learn that the Division was supposed to

1. seek "grass roots" support by securing broad membership from technical and humanistic-social faculty and from administration.
2. concern itself with and promote discusion of integrated humanistic-social programs, courses, and subject matter.
3. promote discussion of problems of humanistic-social education at sectional meetings.
4. assist efforts of all who are interested in developing curricula, training teachers, and publishing papers.
5. help secure more "able, vigorous, stimulating" teachers.
6. secure more interest in our work by people outside of engineering, by members of the College English Association, societies of economists, historians, librarians, sociologists, etc., especially to arouse more interest in teaching engineers.

Now we have a more concrete basis for making judgments. Our membership shows that the "grass" of the "grass roots" support is filling in. Our record of papers given and the consistently high, even inspiring, quality of them shows that we have discussed well the general philosophy of humanistic-social programs, and methods of planning and integrating them, and have taken apart and put together again many specific courses to see how they could contribute to over-all objectives. The Division has encouraged discussion of problems at sectional meetings of the Society, if not by formal action of its officers, then by getting people together and encouraging them to individual activity. It has encouraged publication of papers. These are all significant achievements.

At the risk of being repetitious, let me emphasize that all of this has been particularly important because it has been so closely related to our major job, teaching engineers. Certainly we have talked in general philosophical terms, but always about a philosophy of teaching. All in all we have had a pretty good balance between the general and the specific. And pretty consistently a conventioneer has been able to go home feeling that he had learned something which he could use in his program and in his classroom.

The Future

I hope that we have been humane. Certainly we have been human, for we have not achieved all of our objectives. If what I have already said appears to have been a panegyric, I can perhaps balance it by a statement of certain places where we might do more.

As I state wherein we may have fallen short and suggest some possibilities for the future, please let no one be more embarrassed than I am. After all, as an officer of the Division I have had my chance to function. What I have to say

now is intended not as criticism but as proposal which may or may not deserve discussion.

I have feared lately that perhaps we were not pulling enough engineers into the meetings of the Division, even though in all of them we have engineers as speakers and as audience. It is true also that as we became more independent the technical men who fathered us have felt that their support was no longer so necessary; some falling away was to be expected. But, though we find little evidence that our support in engineering colleges is diminishing, we should watch that the interest of engineers in our convention activities does not drop too low.

And, as we have attempted in the past, we should continue to foster as much mutual understanding and respect as possible. Our success, after all, depends to a considerable degree on the close cooperation of technical and non-technical faculties; this cooperation must in turn be based upon an appreciation by each of what the other is doing. Perhaps some day it would pay for us to explore with technical divisions the ways in which the fields of each could contribute to the work of the other, and make this the subject of discussion at a convention session.

Some care has been exercised to draw into the Division people from a variety of fields in the humanities and social studies. Such attention was necessary because many of our early supporters were from departments of English out of which humanistic-social programs developed in so many engineering colleges. Certainly the more we can bring into our activities the stimulus of varied points of view, the more likely we are to achieve the objectives we have set for ourselves. Continued emphasis on this point is desirable, as can be easily seen by the relative paucity of papers in certain areas and by the few men from some fields who have attended our sessions.

We have not done enough, I should say to acquaint people in other professional societies with what we are doing or why. Such an expansion of a knowledge of our activities is needed for reasons which I need not detail. But certainly if it is good for us to bring people from many fields and from liberal arts colleges into our work, it should be equally desirable for us to go to all the world and preach our particular gospel. I believe we have not done enough to establish relationships with other professional societies or to get our people to try to give papers on their programs so that they may know what we are doing. On this particular occasion a real step is being taken by the cooperation of members of our group in the sessions of the College English Association. This type of activity we should emphasize more than we have in the past.

Training Instructors

Then the question arises as to whether we have done enough to solve problems of securing teachers for the programs we are developing. True, some years ago an investigation was made of the possibility of setting up a program of graduate study which would give special training for work in integrated curricula. This work was dropped, and perhaps rightly so. I myself blow hot and cold on the subject. But I always come back to the conviction that the matter is worth discussing again to see whether we still agree that we should continue taking our teachers from regular graduate programs and then giving them on-the-job training. Perhaps we could, if we concentrated on it, find some way to develop special graduate programs to take care of our special needs, if we agree that we have them.

Closely related to the problem of training instructors for the kind of teaching they may encounter in humanistic-social programs is the problem of their understanding of the technical work which their students are studying and will some day undertake professionally. If our students need to understand more of what we know, in order to be better men and citizens, perhaps we need to understand more of

their work and interests in order to be better teachers. As means to this end, we might explore two measures: (1) the encouragement of humanistic-social instructors taking or auditing technical courses, with all the attendant problems of standards for promotion and maintenance of professional standards, and (2) the participation of our men in activities of those industries which take faculty from technical colleges for full-year or summer programs of study. Possibly the problems involved in these two activities are too many for solution—but investigation of them might be desirable.

Meetings of the Division have shown a remarkable agreement on objectives of humanistic-social programs and have indicated a desire to get down to basic principles in all the fields from which we take material. Factual coverage, we have seemed to state, is less important than understanding and use of fundamental concepts. But just what are the most important principles which are contributed by the various fields of study? Could we find the means of helping each other by drawing up, over a period of years, a suggested list of basic concepts which we all could go to work upon?

System of Exchanges

One final suggestion. We of this Division have met yearly, have discussed our problems, described our programs and thus have given genuine help to one another. But this experience has been in a sense vicarious. We hear what others do; we do not get the chance to do what they do. How much more we could gain from each other if we could work together for a year instead of for a week. What, then, would be the possibility of our Division encouraging a system of exchanges so that some of us could, once in a while, live and work at another institution long enough to become a part of its program? Then we could take back to our own departments not just mimeographed papers or memories, valuable as these have been both to me and to many others; we could take back with us an understanding based on a living experience.

This has been but a brief review and evaluation of the past progress of the Humanistic-Social Division. But to many of us the Division has meant more than any paper could express. Were I to try to put that meaning into words I could do no better than John Shirley did in his introduction to the Selected Papers which the Division has just published.

"Those of us who have attended these discussions have been well repaid; we have been constantly heartened by the serious intent of the men responsible for planning for and instructing the future engineers in the area of the humane and social sciences; we have been frequently amazed at the general uniformity of our conclusions. This is not to say that all of us have thought alike or that a single mold of engineering education has evolved. But the purposes, the intents, and (generally speaking) the methods of approach which have seemed to work have been in greater agreement than we would have believed possible. If nothing else, these meetings of minds have strongly persuaded us that we are proceeding properly, and that the revolution in engineering education which is the reason for our Division's being is working in the right direction. We have been able to return home from these meetings with reinforced strength and with renewed convictions."

Validity of Examinations*

By IRWIN WLADAVER

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I'm going to talk with you about validity of examinations. My immediate purpose is to bring to your attention as clearly as I can the one central issue that in my opinion shows signs of serious neglect.

The issue, as I see it, is this: that validity of examinations is a social achievement and a social obligation. It is not a one-man job. And it is never possible to state that a test or examination (I use these words interchangeably) has 100 per cent validity. The best you can do is to strive to have your test achieve a high degree of validity and, consequently, to have it receive widespread acceptance as a valid instrument. The great problem, then, is (1) to realize that validity involves *people* and (2) that these people can all make contributions toward a *degree of validity* which, by its nature, is not susceptible to precise or even approximate measurement.

I don't want you to think I'm posing as an expert in psychological measurement. In fact I want to acknowledge my great obligation to four particularly useful sources. They appear in the partially annotated bibliography that I've appended to this paper and I hope you will consult them, and the other items, too, when you are ready to do some probing yourself. The four I'm referring to are these:

1. *Validity*, an unpublished paper by Dr. Louis E. Raths, of the New York University School of Education. This is a comprehensive treatment of validity, to which I am most deeply indebted. Besides, it's wonderful reading. I have been profoundly influenced by this work of Prof. Raths and I am grateful to him for his carte blanche permission to adapt his material.

2. *Educational Measurement* (E. F. Lindquist, ed.), a new and absolutely amazing symposium on every conceivable aspect of the subject, by the outstanding people in the United States. The American Council on Education published the book in 1951. Chapter 16, on Validity, is excellent and highly authoritative. Prof. E. E. Cureton of Tennessee and others contributed to the chapter. The rest of the book is equally high in quality and I earnestly recommend it to you for all aspects of educational measurements.

3. *Proceedings of the Engineering Drawing Summer School* (St. Louis, 1946). The whole section on examinations is particularly appropriate. The articles by Professors Viereck, Schuck, and Mann ought to be required reading and Professor Arnold's discussion that followed Dr. Mann's paper on validity was very much to the point of today's topic.

4. *Range of Human Capacities*, by Dr. David Wechsler, is a most provocative book, and anyone who is not afraid of an intellectual challenge to long-standing notions about human capacities ought to read it.

And so you see that the central issue I'm talking about is not a discovery of mine. Nor is it that writers and speakers have failed to mention it before the public. What usually happens, however, is that these persons point out the problem but rarely suggest a course of action that might conceivably lead to a minimum or tentative solution. I'm going to suggest

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some courses of action and see what happens—if anything.

My plan of approach is to delimit the problem, to state certain reasonable assumptions, to give acceptable definitions we can work with and some examples to show how the definitions work. Then we'll be able to attack the subject proper and —I hope—properly.

Delimitations

Here are the things I'm not going to do: I am not going to challenge the whole field of educational philosophy. I'm not going to take on the whole field of educational psychology. I'm not going to take an inexorable stand for or against "objective" examinations, although I do have some serious misgivings about how we arrive at grades for our students. Whether we use objective or non-objective methods of scoring tests or laboratory drawings, I have no intention of thrusting a lance into a windmill; I don't want to get knocked off my mule.

Assumptions

I'm going to assume that it's right to give examinations and to assign grades to our students. We don't have much choice, anyway, do we? Then let's make the process as useful and as meaningful as we can.

I'm going to make this important assumption: that educational measurement in engineering drawing and descriptive geometry has the following major functions, among others:

1. To facilitate learning on the part of our students.
2. To evaluate their work and progress toward the course objectives.
3. To aid in the improvement of instruction or, what is the same thing, to increase our own professional stature.
4. To assist us in counseling our students.

And I might as well add that these are not automatic.

I'm going to assume that, since we are experts in engineering drawing and descriptive geometry, and since we are professional teachers, it ought to be our job to make up examinations designed to serve any specific purpose we think is right; and that it's also our job to investigate the relative validity of these exams.

Definitions

The important words to define and differentiate are reliability and validity, as characteristics of examinations. First, *reliability:* it's easy to explain and easy to illustrate. Reliability is consistency. A test is reliable to the extent that the score will be the same when it is used as a retest—or when alternate forms of the same test are used. It is a matter of statistics *only.* If I score 60 on a test today and 60 on the same test tomorrow, then the test is 100 per cent reliable. It doesn't make the slightest difference what the test is on. The content is immaterial.

I'll give two more examples: If your watch keeps perfect time, but you happen to have set it fifteen minutes slow, your watch is perfectly reliable. Statistically, the reliability coefficient is unity. You may miss your class every day, but your watch is reliable in the sense we're talking about. Maybe you will have no job, but you have a reliable watch.

And if I tell you, day after day, that I caught a fish that long, the story is absolutely reliable as long as the fish neither stretches nor shrinks. Maybe I'm a liar, but I'm a reliable liar. You can depend on me to report the same lie.

Thus it is that reliability is a matter of statistics. A test may have a very high reliability coefficient and all that it means is that you are measuring consistently whatever it is that you are measuring. But high statistical reliability of an examination is no assurance that the exam has high, low, or any other degree of validity —or for that matter any validity at all.

The only connection between reliability and validity is this: If you can show by a number of non-statistical operations that

the test has certain kinds of validity, then proof of reliability is an additional piece of evidence in your claim for *greater* validity.

Validity

Now what do we mean by the word *validity*? To ask the question is to imply that it has a single, unique meaning. Unfortunately, this is not the case. It's easy enough to give a commonly accepted definition such as: "Validity is the extent to which a test measures what it purports to measure," or such as "The essential question of test validity is how well a test does the job it is employed to do." Both of these general statements are fine and no one quarrels with them. But from the standpoint of what to do, they are silent. They are not specific. They have no real meaning because they are empty of operations. What we have to know about a test or examination is this: what must we *do*, what steps must we *take* to determine its relative validity? Can I do it myself?

No. You can't do it yourself. No single individual can. If you look closely at the definition, you will see that human judgment is called for at every turn. The definitions say "how well," or " to what extent." The person who asks the question cannot also answer. It is true that an individual can do certain things himself. He can make tests of reliability, can get professional advice and can make improvements in the test arrangements and thus contribute to validity, but he alone cannot be the last word. Only through a period of time and use, in your school and in mine, can any test in a broad field like drawing achieve validity. For this reason, as I said at the outset, the determination of validity is a social achievement.

Let's suppose we have before us a test that we want to validate. There are four things, at least, we ought to consider and agree on. Otherwise we are beaten before we take a step.

1. We must agree on a definition of what we are trying to measure by the test.
2. We must agree on the responses that we shall consider evidence of the presence or absence of what we are trying to measure.
3. We must agree on what constitutes relative amounts of what we are trying to measure and on the way to estimate the probable error of measurement.
4. We must agree on the probable significance of the results in the general educational and professional growth of our students.

You can argue about any one of these four points—you probably do—but we must reach some workable and realistic compromise. It should be perfectly obvious, then, that a test-maker must be competent, capable of distinguishing the critical, the important, the relevant and the trivial elements. He must have no pet peeves and no pet devices that he feels he must spring at every opportunity. And of course he must be informed. Without these qualities, his judgment, for any intellectual purpose, must be suspect.

I said earlier that validity does not have a single, unique meaning. You should infer from this that the different concepts of validity depend upon the points of view from which you attempt to reach it. I'm going to cite eleven different, but sometimes overlapping, points of view from which to judge the degree and the kinds of validity which your test may have. Then I'll try to explain what I mean by each of them.

1. The extent of agreement between the test-results and some informed, competent criterion outside of the test.
2. The determination of validity through the use of criterion groups.
3. The extent to which predictions made on the basis of test-results come true.
4. The extent to which the operations required of the student—by the test—are in agreement with the title and the purpose of the test.

5. The extent to which the subject-matter content of a test is in agreement with the title and its implications.
6. The extent to which a test incorporates important items and excludes non-essentials, and how nearly the test parallels good teaching practice.
7. The extent to which a test contributes to the educational and professional growth of the student; that is, the extent to which a test reflects the career for which a student is presumably preparing, and the effectiveness of this kind of validity on counseling and advisement.
8. The extent to which parts of a test are themselves valid as part scores.
9. The extent to which the test correlates with other records—and the extent to which such correlation is of little use or even spurious.
10. The extent to which statistical analyses of the test and of individual items of the test contribute to validity.
11. The extent to which the actual construction of the test conforms to sound practice and so contributes this kind of validity.

1. *The extent of agreement between the test-results and some informed competent criterion outside of the test.*

By this I mean the judgment of competent persons who know the purpose of the examination. For example, ask a capable teacher to rank your students in order of merit with respect to the particular trait you are testing for. Naturally, this teacher should have opportunities to judge the students in action. Then give the exam and score it. If there is substantial agreement between the test results and this informed, competent criterion, then you have the right to say that the test has some degree of this kind of validity. Naturally, the teacher who has done the ranking ought to be competent and informed and ought to know what can be expected. Generally you will have such persons working with you.

Sometimes individual ranking isn't possible, for one reason or another. In such a case, have the students divided into a number of groups, say five: excellent, good, average, below average and poor. And then give the test. Divide the test-scores the same way and see whether your "excellent" students make "excellent" grades, and so on down the line. If your "excellent" students make "average" scores, you may want to take some steps. If your "excellent" students make "poor" scores, you draw your own conclusions; surely some changes are in order. Perhaps you may come to believe that the other fellow's judgment was not good and that the test actually had high validity from the standpoint of teacher-opinion. That's up to you. But you can see why it's important to select a competent and informed criterion that you can stick with.

2. *The determination of validity by use of criterion groups.*

By a criterion group I mean a group of persons actually working in the field for which our students are preparing. If you say you are training for draftsmanship, select draftsmen for your criterion group. If you say you want to teach your students what a good engineer ought to learn from your drawing and descriptive geometry courses, then select engineers, preferably not your former students. The group you select should depend on the goals and objectives you say you have been trying to reach. Presumably the persons you select for your criterion group will be homogeneous; with respect to what you want to know, their behavior will be similar.

What you want to know is this. How did your school work in drawing help you in your present work? Was the information useful? Were the experiences useful? Have you any suggestions? What are your attitudes? What mistakes did

we make? These are just a few off-the-cuff samples of questions you might ask.

To the extent that there is correspondence between your test-results and important factors related by your criterion group, this kind of validity may be present.

I must point out some dangers in this procedure. Oftentimes young graduates, especially your own former students, will tell you what they think you want to hear; especially what a terrific job you did on them. Believe it, if you must. But it doesn't give you much precise help.

Sometimes it does. A few weeks ago, my daughter said to me, "Dad, what's a left-hand screw-thread?" Naturally, I started to explain. But she added, "I really don't care. All I wanted to say was that I met a boy" (of course I was glad to hear this), "a boy who had you in drawing six years ago. The only thing he remembers about your course is that you used to drive a taxicab nights when you went to college and that one of the wheels of the Yellow Cab Company cars had a thread that went the wrong way and you didn't find out for an hour after you got a flat tire." This he remembered.

So I say this kind of information may be useful in your quest for validity of examinations and it may not.

3. *The extent to which predictions made on the basis of test-results come true.*

If high grades in a drawing test were fairly sure indications that a student would be a successful engineer or draftsman, you could say the test had high validity of this kind. That is, you could make predictions that would be verified in action. Isn't this what intelligence tests and aptitude tests mean to do? If they fail to predict fairly accurately, they lack this important aspect of validity.

This ought to be a good topic to investigate if you have a comprehensive test in drawing or descrip. See how closely your test-results correlate with the graduating averages of your students. Maybe there is some predictive validity present. And if there is, be sure you don't claim a cause and effect connection.

4. *The extent to which operations required of the student—by the test—are in agreement with the title and the purpose of the test.*

To me, this seems like the most important step of all in the search for evidence of test validity. Suppose you were giving a test in a student's understanding of the principles of sectional views. If you wanted to know whether he could identify a properly drawn sectional view, given two exterior views, this would be one kind of operation at an easy identification level. (I recommend Prof. Graney's illustration along these lines on page 343 of the 1946 Summer School *Proceedings.*) How *much* validity an identification test has for what you are after is certainly open to question, but it surely has *some.*

If, however, your test requires that a student draw an indicated Section A–A, your test is likely to have *more* validity for an understanding of the principles of sectioning. And if you go all the way and say, "Draw the most useful section of the object," then you are really in for it. You have to presuppose all sorts of things and hope that the student's judgment coincides with yours.

The point I'm trying to make is this: if you say the test is a test of a student's ability to think, you ought to be able to show that it does indeed measure that ability. This will take some doing.

If you dare to say that the examination is a test of a student's ability to think *creatively,* I urge you to define your terms with scrupulous care and then show evidence that the test does indeed measure *that* ability.

This is a good time to remind you that students in some subjects forget from 40 to 80 per cent of the facts they once learned within three months to three years. If your test is designed to ask for facts only—and it's a perfectly justifiable kind of test—you should realize that *what* a student learns is not so important as *how*

he learns it. I think Professor John Rule's article in the May, 1953, *Journal of Engineering Drawing* carried this same implication.

To the extent that the mental operations of learning are called for on an examination, a claim for test validity can be reasonably supported.

5 and 6. *The subject-matter content of* a test can readily be checked against tables of contents of good textbooks; and comprehensive sampling of the field. If that's what you want, it's not hard to demonstrate. Also, if you consult with a few of your colleagues it will not take long to eliminate most of the trivia. But don't think that therefore your test is necessarily valid. All you have done is added a little weight to the balance. And you should be careful not to introduce into an exam unusual or new elements that you have not dealt with in class unless, of course, you think they are reasonable outcomes.

7. *Tests* in our field of engineering drawing and descriptive geometry can contribute solidly to professional and educational growth of our students by *reflecting the career* for which they are preparing. It may be clear to you what an important influence on our counseling duties a good test can have. It should warn us not to try to play the part of an all-wise deity, lacking omniscience as we do, but in some fields tests have reached the quality that permits advisors to make recommendations that otherwise could not be justified.

Whether our examinations are yet good enough is something else, but this is a kind of validity we should certainly strive for.

8. When *parts of a test* are *valid as part scores,* there are obvious advantages to the student who wants to know what partial progress he has made and also to the teacher who can be reasonably sure where deficiencies in learning and teaching exist. This is another kind of validity in the overall worthwhileness of a test.

9. *Correlations are often reported as evidence of test validity.* I'll go along with some. For example, if a test has a high reliability coefficient, there is no automatic assurance that the test is valid, but only that it has the kind of validity that self-consistency offers. However, if a test has a low reliability coefficient, then the test validity for any purpose must be seriously in doubt.

But there are other correlations that serve little use. Don't condemn a test simply because it doesn't correlate well with other records—high school records, for example. And more than anything else about correlations: don't attribute high validity to a test on the basis of its high correlation with another test assumed to be valid. As I see it, this begs the whole question of validity. An assumption of validity may be necessary—we do it all the time. But trying to prove validity by correlation with something assumed to be valid hardly seems the way to go about it. This is an understatement.

10. I shall probably lose some friends when I say I'm quite uncomfortable about the next matter. This has to do with *test-validity contributed by statistical analyses* of the test and of items in the test.

I guess I don't actually understand some of the statistical manipulation. Most of the formulas, unless I'm mistaken, make an important assumption: that the trait being tested is normally distributed. I have seen no evidence that this is true in drawing. And there are other assumptions, generally not expressed, that seem to me to have shaky foundations. In addition, most of them involve nasty and forbidding algebra.

For these reasons I question the usefulness of some of the statistical analyses in the claim for validity. If you are interested in statistics, read Professor Cureton's article called, "Validity, reliability and baloney." You'll find it listed in my bibliography.

11. The last item has to do with the *validity* contributed to a test *where a test is made up in conformance with sound and informed construction practice.* This is a matter about which any interested

person can be well posted if he takes the effort. In the bibliography I cite a small number of articles you may wish to read. They are on such subjects as: scoring examinations; problems in the use of answer blanks; examination fear; comparisons of true-false, multiple choice, completion-questions; and other related topics. And all of these have to do with validity to a greater or lesser degree.

Conclusions

Well, these are most of the operations reported in the literature on validity. There are only these last two brief but tremendously important points I feel I must make.

First, we must be constantly aware of the educational purpose of every test we give. The best way to stay alert to this is to state its purpose so that we can try to evaluate its influence on validity. Examinations to determine grades are certainly necessary, but a far greater purpose—perhaps the ultimate purpose—is the development in our students of resourcefulness and ingenuity.

Second, we are not hermits. Our students are working at their careers all over the country and all over the world. We are not even preparing all of them to practice engineering. We must test for knowledge, of course. But we should be testing for the kind of knowledge that leads to informed, socially desirable action. One way we can come close to this objective is to work out our testing problems together—actually to send copies of our examinations to colleagues in other schools, to use the exams in our classes, to criticize unstintingly and suggest improvements—and to accept such recommendations in a grateful spirit.

Wouldn't it be wonderful if we could say something like this: "Yes, we've trained these young people pretty well so that they can get off to a good start in the engineering profession. But more than that, we've helped them along to an education that will help them to live useful, productive, fruitful lives in any activity they ever choose." If our examinations have the kind of validity that will let us believe that this is really true, then we can indeed be proud of the work we are trying so hard to do.

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Minutes of General Council

A meeting of the General Council of the American Society for Engineering Education was held Wednesday, October 14, 1953, at 2:00 P.M. in the ASCE Board Room of the Engineering Societies Building, New York, N. Y. Those present were: L. E. Grinter, *President;* W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents;* A. B. Bronwell, *Secretary;* G. W. Farnham, *Treasurer;* J. M. Apple, H. H. Armsby, H. R. Beatty, C. A. Brown, N. A. Christensen, W. L. Collins, W. W. Dornberger, T. H. Evans, O. C. French, G. W. Gleeson, W. P. Godfrey, S. C. Hollister, H. K. Justice, H. Kuenzel, H. R. Lissner, G. D. Lobingier, G. A. Marston, R. S. Paffenbarger, H. P. Rodes, Thorndike Saville, R. J. Seeger, J. W. Shirley, E. B. Stavely, L. E. Stout, R. L. Sumwalt, N. D. Thomas, R. W. VanHouten, R. E. Vivian, K. F. Wendt, C. L. Wilson and M. Long.

Report of the Secretary

The Secretary reported the following:

1. Most of the ASEE Committees have been appointed for the year.
2. A number of the Divisions and Committees had taken advantage of the Fall Meeting program to get their executive committees together to discuss the projects for the year.
3. The Membership Drive this year will be conducted by the YET Committee. The Secretary urged that members of the Council and Deans back up the YET Committee in this activity.

Report of the Treasurer

The Treasurer presented the Statement of Receipts and Disbursements for the First Quarter of 1953–54. Both income and expense items seem to be in line with the budget. The University of Florida has rebated $527.27 as the excess of income over expense for the Annual Meeting.

Airforce ROTC Quotas

Vice President Everitt stated that the ECAC had been called upon to consider the problem of whether or not the Air Force ROTC had committed a breach of contract or moral commitment in reducing its quota of ROTC Students. He pointed out that a year ago, the Air Force had set very high quotas for its ROTC program but now it has drastically curtailed this program after having induced college students to participate. A study by Dean Easton, Chairman of the ECAC Military Affairs Committee showed that:

1. The Air Force ROTC contract which the student signs does not commit the Air Force to continuation of the student's ROTC program;
2. The ASEE had objected to the very large ROTC quotas set by the Air Force last Fall, hence any reproaches to the Air Force at this time would be a reversal of previous ASEE policy;
3. A survey of deans of some of the engineering colleges indicated that they did not feel that it would be wise to protest the ROTC reduction.

In view of these findings, the ECAC took no action in the matter.

Activities of ECRC

Vice President Walker discussed the activities of the ECRC and stated that the theme "Creativeness in Engineering" has proved to be a very popular subject and would be given considerable emphasis by ECRC at the Annual Meeting. He also stated that the ECRC had sold 800 copies of the Directory of Research, published last June, which has received exceedingly favorable reviews.

Plans for the Annual Meeting

Vice President White summarized the recommendations of the Committee on Annual Meeting relating to the program for the University of Illinois Meeting in June as follows:

1. The Committee proposed a continuation of the plan for General Sessions which was used last year.

a. A General Session to report on some of the prinicpal Society projects on Monday afternoon (some Division Conferences can be scheduled concurrently with this General Session);
b. A General Session of the Society on Tuesday morning;
c. General Sessions on Wednesday and Thursday mornings sponsored by the ECRC and ECAC;
d. General entertainment on Wednesday evening;
e. The Banquet on Thursday evening.

Proposed Amendment to ASEE Constitution and By-Laws relating to Dues of Individual Members

The recommendation of the Committee on Society Finances relating to a change in the dues status of individual members in order to provide adequate income for Society operations was reviewed.

The Secretary stated that the new proposal would establish a two-step dues structure based upon the age of the individual member, with the dues increasing automatically when the member becomes 36 years of age. The previous dues plan was based upon academic rank, necessitating a time-consuming study of the membership records each year in order to determine changes in academic rank before the dues could be evaluated for individual members. The proposed plan would eliminate this office procedure. The following amendments were voted by the General Council:

Amendment to Article XI—Section 2

Present Wording: The annual dues shall be as stated in the By-Laws of the Society, and any change in the dues of individual membership shall be determined by letter ballot of such membership.

Proposed Amended Wording: The annual dues shall be as stated in the By-Laws of the Society.

Amendment to By-Law IV:

This By-Law now specifies the dues of individual members as: $5.50 for Librarians and grades under Associate Professor, $6.00 for Associate Professors and $7.00 for all others.

Proposed wording of Amendment: "The dues of members shall be established annually by the General Council at the same Council Meeting at which the annual budget is adopted. The dues shall be adjusted within the ceilings hereby established so that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger its continuity of operation. The increase of dues approved in any one year shall not exceed $1.00 for either grade of membership described herewith. The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members."

Amendment to By-Law IX

Present wording of By-Law: The dues of individual members may be changed only by a favorable vote by letter ballot of individual members.

Proposed amended wording: The ceilings of dues of individual members as specified in By-Law IV may be changed only by a majority vote by letter ballot of individual members.

In the discussion that followed, it was pointed out that if the dues of individual members were increased to $8.00 for members over 36 years of age, and $6.00 for members under 36 years of age this would provide adequate finances for Society operations at the present time.

The General Council voted unanimously to approve the foregoing amendments to the Constitution and By-Laws and authorized the Executive Board, after consultation with the Committee on Constitution and By-Laws, to adjust the wording to avoid possible confusion and misunderstanding. The Council agreed to an inclusion of a statement specifying the dues for the year 1954-55 in order to provide the necessary transition from the academic rank basis to the age basis of levying the dues.

Evaluation of Engineering Education

President Grinter summarized the latest developments of the Committee on Evaluation of Engineering Education, stating that three of the Sub-Committees had completed their preliminary reports and that these were being mailed to the Deans of Engineering Colleges and the Chairman of the Institutional Committees for their comments and suggestions for improvement. These

criticisms will be analyzed by the Secretary of the Committee on Evaluation of Engineering Education. This analysis will be available prior to the next meeting of the Committee on Evaluation of Engineering Education, at which time the final report will be drafted.

Dr. Seeger, Chairman of the ASEE Physics Division, stated that the Physics Division had called a meeting of the Sub-Committee on Physics of the ASEE Committee on Evaluation, together with the Executive Committee of the ASEE Phyiscs Division and the AAPT Committee on Physics in the Engineering Curriculum. This meeting recommended the following: (1) That the Deans of Engineering Colleges and the Chairmen of the Physics Departments be asked to appoint local joint committees to study the place of Physics in the Engineering Curriculum. (2) That the report of the Committee on Evaluation of Engineering Education withhold final judgment on matters relating to the teaching of Physics until there has been widespread discussion of this problem among engineering and physics teachers (3) That a joint meeting of the Physics Division of the ASEE and several curricular committees be planned for the Annual Meeting of the Society to discuss both the prospects of including fundamental material in the newer areas of Physics in the Engineering Curricula and also the possibility of achieving better integration of Physics in Engineering courses at the freshman or sophomore level. (4) The Committee recommended that a joint symposium on this subject be arranged for the AAPT meeting in January.

ASEE Sponsored Summer Institutes

The Secretary reviewed the recommendations relating to the Summer Institute Programs resulting from the morning meeting with the Chairmen of Divisions and representatives of the General Council. The objective of this program is to identify those areas where science and technology are moving rapidly ahead and where there appears to be opening up vast areas of new fundamental concepts which may be translated into significant engineering practice in the years ahead. Conferences would then be arranged in these particular areas to explore the subject matter from a teaching viewpoint. The conference in the morning recommended the following:

1. Approval in general principle of the plan of holding Summer Institute Conferences.

2. All proposals for Summer Institutes shall be submitted by one or more Divisions of the Society to the Executive Board for approval.

3. No attempt shall be made either to develop a Summer Institute program or solicit finances without prior authorization from the Executive Board.

4. After approval of the Summer Institute program, the participating institution or institutions may seek funds for financing the conference, within the general principles approved by the Executive Board.

5. An objective of the Summer Institute Program is to encourage publication and widespread dissemination of the results, including the possible preparation of textbooks in the field.

6. The Summer Institute Programs can be jointly sponsored by other societies participating with ASEE, but the ASEE should have primary responsibility for such conferences in order to assure that the efforts will be directed so as to achieve best results for the purposes of engineering education.

Progress Report of Committee on Society Functions

Vice President Teare summarized the present thinking of the Committee on Society Functions. The Committee is endeavoring to seek a better two-way flow of ideas between the General Council and members of the Society. It is seeking to make individual units in the Society more effective. It is considering the relationships of the Council, Divisions, Committees and Sections of the ASEE from the standpoint of achieving best operational results. It is giving consideration to the service of the Society to the individual member.

Council members discussed the possibility of having the Chairman of the Division serve as a Member of the General Council in order to improve the liaison between the Divisions and Council. Several of the Council members stated that the practice of their Divisions was to elect a past chairman to serve on the General Council. In this way the representative on the General Council

is fairly well informed of the Division operations.

President Grinter asked for the consensus of opinion as to whether or not it was desirable for the Chairman of a Division to serve as the Council representative. The majority view of the Council opposed this plan.

The Council discussed the possibility of redefining the boundaries of Sections in order to make it possible for younger teachers to attend. It was suggested that the reason why Young Engineering Teachers do not attend Section meetings is because they do not feel they have a part in the meeting. Having no participation in the Section meetings, they have no reason for developing an interest in Society activities. President Grinter strongly urged that the Sections take steps to bring the younger members of the Society into active participation in Section meetings and that other areas of Society operations do likewise.

The Council requested that the Committee on Society Functions study specifically the problem of how younger faculty members can be better integrated into Society activities.

ASEE Sponsored Summer Schools

The following summer schools have been proposed by ASEE Divisions to be held at the University of Illinois either prior to or immediately after the Annual Meeting.

1. A Summer School in Machine Design has been proposed by the Mechanical Engineering Division, to be held during the week following the Annual Meeting. This will deal with various aspects of teaching Machine Design subject material.

2. The Mechanics Division has proposed a Summer School on graduate study in Engineering Mechanics and its relationship to undergraduate instruction. This Summer School would be held on June 11–12 prior to the Annual Meeting.

3. The Humanistic-Social Division has proposed a Summer School on Friday and Saturday following the Annual Meeting in order to develop the proposed project on Humanistic-Social Studies.

4. The Educational Methods Division and the General Electric Company have jointly proposed a Summer School to be held at Schenectady for a limited number of young instructors to acquaint them with teaching methods used in the advanced engineering course at the General Electric Company.

5. The Engineering Economy Division has proposed a Summer School to be held on June 13–14 dealing with analytical tools in engineering economics, including: (1) operation research, (2) accounting and economics.

The foregoing Summer Schools were approved by the Executive Board and the General Council.

Joint Conference with Instrument Society of America

The Instrument Society of America has proposed a joint conference on the teaching of instrumentation to be held on Saturday preceding the Annual Meeting at the University of Illinois. This would be a one-day conference, the program being arranged jointly by ISA and ASEE. The Executive Board and General Council voted to authorize ASEE sponsorship of this Conference.

YET Paper Contest

The Secretary reported that the Executive Board suggested continuation of the YET contest and had authorized two awards at $200 and $100 to be known as the "President's Award," which will be presented at the Annual Banquet to the wininng entries. The rules of the contest as published in the October issue of the JOURNAL are similar to those of last year, except that the method of judging the papers has been simplified. All papers must be submitted before March 1, 1954, to the Chairman of the ASEE Section in which the author resides.

Life Memberships

The General Council voted to grant life membership to the following members who qualify:

J. A. Van Den Brock	Leroy A. Wilson
M. O. Withey	Leonard A. Doggett
F. H. McClain	Joseph S. Lambie
Harold C. Bird	Arthur G. Gehrig
F. M. Marquis	Morland King
W. H. Hall	J. B. Kommers
Jerome W. Howe	

Associate Institutional Membership Applicants

The Executive Board and General Council voted to grant Associate Institutional Mem-

bership to the following companies:

1. The Cleveland Electric Illumination Company
2. Ethyl Corporation Research Laboratories
3. Rome Cable Corporation
4. Weston Electrical Instrument Corporation
5. Public Service Electric & Gas Company

The Executive Board and General Council also voted to grant Active Institutional Membership to the University of Wichita.

Dues of ECPD

The Executive Board and General Council voted to increase the annual appropriation to ECPD to $700 as requested by ECPD.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Reprints Available . . .

Are you interested in receiving copies of the newly completed "Manual of Graduate Study" or the "Report of the Committee on the Improvement of Teaching"? Copies of these can be obtained from the Secretary's Office, the price of the Graduate Manual being 50¢ and that of the Report of the Committee on the Improvement of Teaching being 15¢ each or $8.00 per hundred. All orders should be accompanied by a check remittance.

THE T-SQUARE PAGE

Officers
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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

HAROLD P. SKAMSER, *Editor*
Michigan State College

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Dear Colleagues:

I wish to take this opportunity to extend to you a cordial invitation to be present at the meetings of the Drawing Division during the coming year. With the present trend towards changes in the engineering curriculum, you cannot afford to miss the two meetings of the Division this year.

The program of the Midwinter Meeting as arranged by Prof. Jorgensen in cooperation with your chairman, and being held at the University of Pennsylvania has been planned with the objective of the technical and cultural development of the engineering drawing faculty.

Also, do you realize that this is the twenty-fifth year that the Division has held independent meetings, and that we are one of the largest divisions of the A.S.E.E.?

These thoughts are receiving serious consideration in the planning of the June meeting.

Your Executive Committee selected Philadelphia for its Midwinter Meeting because of its accessibility and the excellent facilities for technical and cultural trips.

After looking over the fine program, I am sure you will say with me—"I just can't afford to stay away."

I hope to see you in Philadelphia, so be sure to save the dates.

Sincerely yours,

RALPH T. NORTHRUP, *Chairman,*
Drawing Division, A.S.E.E.

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Midwinter Meeting of the Engineering Drawing Division of the A.S.E.E.

UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PENNSYLVANIA
JANUARY 28, 29, AND 30, 1954

Thursday, January 28:

6:00– 8:00 p.m. Executive Committee Dinner and Business Meeting—Bishop White Room, second floor, Houston Hall

Friday, January 29:

10:00–12:00 noon — General Session—Room 314 Engineering Building

Chairman: Professor John G. McGuire, Texas A. & M. College

Technical Papers:

(a) "The Design of Inflatable Boats," Mary Blade, Assistant Professor of Engineering Drawing and Machine Design, Cooper Union, New York, Ellis Blade, Consulting Engineer, New York

(b) "Drafting Problems in Industry and Some Solutions," R. W. Pearson, Manager Operations Programming Section, Engineering Products Department, Victor Division, R.C.A.

Discussion:

12:15– 1:15 p.m. — Luncheon and Business Meetings—Smith Room, second floor, Houston Hall

Presiding: Professor Ralph T. Northrup, Chairman Drawing Division A.S.E.E.

6:00– 7:15 p.m. — Annual Dinner (Ladies Invited)—Smith Room, second floor, Houston Hall

7:30– 9:00 p.m. — General Session—Auditorium, second floor, Houston Hall

Chairman: Professor Albert Jorgensen, University of Pennsylvania
Technical Papers:

(a) "Specialized Drawing Courses Above the Freshman Level," Professor Randolph P. Hoelscher, General Engineering Drawing, University of Illinois

(b) "Drafting Problems in the Bearing Industry," Sven Neilsen, Assistant Chief Engineer, S.K.F. Industries, Philadelphia, Pennsylvania

Discussion:

Saturday, January 30:

9:00–11:30 a.m. — General Session—Room 314 Engineering Building

Chairman: Professor Theodore T. Aakhus, Vice Chairman, Drawing Division A.S.E.E., University of Nebraska

Technical Papers:

(a) "Graphics for Non-Engineers," Professor R. W. Parkinson, The Ohio State University, Columbus, Ohio

(b) "Vanishing Points and Shadows in Three Point Perspective," Professor Wayne Shick, University of Illinois

(c) "Three Dimensional Nomograms," Professor Douglas P. Adams, Massachusetts Institute of Technology, Boston, Massachusetts

Discussion:

11:45– 1:00 p.m. — Luncheon (Ladies Invited)—Smith Room, second floor, Houston Hall

Candid Comments

What Can the Engineering School Do About It?

Reflections on J. R. Snell's Article "Let's Clean House" *

By W. E. HOWLAND

Professor of Sanitary Engineering, Purdue University

The corruption, revealed in this article, which results from collusion between public officials and business enterprisers is of course shocking—it always is. Civil engineers are especially concerned to read this bitter indictment of the construction industry, with which they must, of necessity, work very closely. The real shocker, however, is the accusation of moral turpitude of the engineers themselves. One wonders how far the ethical corrosion has extended into the structure of the engineering profession.

Our students wonder, also, when they hear of such stories as these; and they do! There can be no doubt that many of our most promising young men have thus been dissuaded from the pursuit of civil engineering, especially from construction and from those branches most exclusvely concerned with public works.

I have no additional facts to help determine how great the moral damage to engineers has become, a question that naturally arises from reading so disturbing a paper, but I would like to point out that the evidence submitted should not cast suspicion upon the rank and file of the engineering profession,—that is to say upon the men who do the work. Nor, I believe, was it intended to do so by the author. There is little indication in the article that the young men fresh from engineering college are so weak in moral fiber, so destitute of professional idealism, or so uninformed about ethical principles as readily and rapidly to fall into the evil practices here exposed. Furthermore they do not have the opportunity to offer "kickbacks" until they are high up in an engineering firm. And the good and honest work they have done and have been taught to do as professional engineers at the drafting board or in the laboratory has not led them into the indicated unethical practices of certain members of the higher echelons of the engineering business. It may well be that there is little available evidence of corruption of any but the non-engineering employers or business representatives of engineers (who sometimes appropriate the name of consulting engineers)—men who have been so long away from the wholesome discipline of nature's laws and so exclusively concerned with the business of making money (and reducing their taxes) as to have become—as some others are reputed to be in commerce and law—ripe for rottenness and, at last, the bad apple in the barrel to spread corruption.

This article appears in the *Journal of Engineering Education* whose readers are mainly teachers in engineering schools. What can we pedagogues do about unethical practices that are so contrary to our teachings and, apparently, are learned long after college mainly by certain members of the more elevated brass. Frankly I do not know. My only thoughts are that we should constantly reexamine our own

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behavior as engineers and remove every trace of evil that we may find, reemphasize our ethical convictions in all our teachings and then *stick to our task of educating professional engineers* rather than to try also to produce practical men of business. By professional engineers I mean those with the high skills, advanced knowledge, and the earnest desire and firm will to do the best and most economic job. By practical men of business I mean men who have learned to "adjust" to the ways of the world and whose primary motivation, by their own admission, is profit rather than performance. The engineer must be taught to understand and then to *resist* the allurements of easy money and to stand firm against the threats of loss of a job to which engineers have always been subjected by promoters and politicians—by the former no less than by the latter and in "business" administrations as in any others.

Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.

In Memoriam—H. P. Hammond

Dr. Harry P. Hammond, who retired on Sept. 1, 1951 as dean emeritus of the School of Engineering at The Pennsylvania State College, passed away on October 21, 1953 at the age of 68.

Recognized as one of the leading figures in the field of engineering education in the country, Dean Hammond during his 14 years at Penn State won two of the top national engineering awards. In 1945 he was presented the Lamme Award, the highest honor in engineering education, while in 1950 he was given the James H. McGraw Award in Technical Institute Education by the American Society for Engineering Education. Last June he was one of two leaders in engineering education to be named honorary members of the Society, one of the few times the honor had been conferred in the 61-year-old history of the Society.

Dean Hammond was named to the faculty at Penn State in 1937 to succeed the late Robert L. Sackett as dean of the School of Engineering. During his years as dean, the School of Engineering was built from a school with 1,000 students to one with more than 2,500 students. The research program also made tremendous gains with the addition of the Ordnance Research Laboratory as well as other programs so that today Penn State ranks high among the colleges of the nation in funds budgeted for research in engineering.

Physical facilities of the School also expanded during Dean Hammond's years on the faculty. The Electrical Engineering Building was completed in 1939 and the Civil Engineering Surveying camp was constructed in 1940. The Climatometer of the Department of Engineering Research was built in 1942, the Ordnance Research Laboratory and its Moshannon Field Station completed in 1945, and the Garfield Thomas Water Tunnel was opened in 1950. New units to the Mechanical Engineering Building were started prior to his retirement.

Dean Hammond's career as a practicing engineer included experience with the American Bridge Co., the Board of Water Supply of the City of New York, the Miami Conservancy District, and the firm of consulting engineers of Lederle and Probost. His field of specialization was sanitary engineering and structures.

During World War II, Dean Hammond served as a member of the National Advisory Committee of Engineering Defense Training and was in charge of the inspection of Army Specialized Training program units in the Third Service Command.

Dean Hammond served also as a specialist in higher education, making surveys of engineering education in Georgia, Missouri, Brown University, Cooper Union, Catholic University, and Virginia State College, and as chairman of a panel of the Service Academy Board for the U. S. Military Academy and the U. S. Naval Academy. He was chairman of the committee of the American Society for Engineering Education which submitted what are considered as the two most fundamental reports on educational policy in recent years, the reports on the Aims and Scope of Engineering Curricula and on Engineering Education After the War.

From 1924 to 1927, Dean Hammond was associate director of a comprehensive study known as the "Investigation of Engineering Education," which was sponsored by the American Society for Engineering Education. He was an active member of the organization, serving as vice-president in 1934–35 and as president in 1936–37. He was one of the organizers of the Engineers Council for Professional Development and also helped to organize and served until last year as chairman of the Council's Committee on Technical Institutes.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh		W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	University of Pennsylvania	Dec. 5, 1953	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Library of Congress	Feb. 2, 1954	C. H. Walther, George Washington University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

*No Date Set.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR OR ASSISTANT PROfessor, to Teach in the Field of Machine Design. M.S. and practical experience desirable. New building with excellent teaching facilities and opportunity for research. Reply to: V. M. Faires, Mechanical Engineering Department, North Carolina State College, Raleigh, North Carolina.

ASSISTANT PROFESSOR—TO TEACH Airplane Design, Aircraft Structures, and related subjects in the Aeronautical Option in Mechanical Engineering Department. Applicant should have Master's Degree or equivalent experience in aeronautical field. New building with excellent teaching facilities and opportunity for research. Application should be sent to Professor Robert M. Pinkerton, Mechanical Engineering Department, North Carolina State College, Raleigh, North Carolina.

INSTRUCTOR OR ASSISTANT PROfessor of Electrical Engineering (Power). At least B.E.E. required. Appointment immediately or February, 1954. Apply to Dean, School of Engineering, University of Virginia, Charlottesville, Virginia.

INSTRUCTOR OR ASSISTANT PROfessor in Civil Engineering, preferably with M. S. degree and practical or teaching experience; major interest—fluid mechanics. Position open fall, 1954. Department of Civil Engineering, Rose Polytechnic Institute, Terre Haute, Indiana.

INSTRUCTOR OR ASSISTANT PROfessor of sanitary engineering: M.S. desired, but not required; to teach undergraduate sanitary engineering courses and to do research in sanitary industrial fields; eleven months service. Position available anytime before February 1, 1954. Apply to Chairman, Department of Civil Engineering, State College of Washington, Pullman, Washington.

INSTRUCTOR OR ASSISTANT PROfessor of Electrical Engineering. Prefer one with interest in power. At least M. Sc. desired, or possibility of obtaining same soon. Position available immediately, or February 1st. Salary depends upon experience. Send application to Chairman, Department of Electrical Engineering, University of Nebraska, Lincoln, Nebraska.

Report of ECAC Manpower Committee

The following is a report of the ECAC Manpower Committee based upon surveys of industry and data obtained from the U. S. Office of Education.

Current Needs for Engineering Graduates

Unfortunately, returns from the Survey of Industrial and Governmental Organizations have been delayed unexpectedly, primarily because a request for salary information was included on the questionnaire. Returns thus far, therefore, do not justify definite conclusions concerning the magnitude of this year's demand. The attached table gives merely preliminary results from information received from a few industrial groups, where the sample is sufficient to have some reliability.

In general, the companies responding thus far include a distinctly higher proportion of small organizations than last year, in part, at least, because an effort was made to get more adequate coverage from them.

Other information in the table refers primarily to requirements from the current classes. Information was also requested concerning needs from earlier classes, but since they will be filled with men from other organizations, no report is made concerning them here.

In view of the smaller class this year, it is natural that the 1952 expected employment should be less than the 1952 actual employment. On the other hand, 1953 requirements are one-third more than the expected employment.

You will recall that the 1952 survey indicated a demand for about 40,000 new graduates, with about 25% of it coming from civilan government agencies. The tentative conclusion may be drawn from these data that the industrial demand this year will be of the same order of magnitude. We do not yet have sufficient data from governmental agencies to justify the conclusion concerning their demand, but it may be assumed from other evidence that it will be less than last year.

Supply of Engineering Graduates

The next table gives some estimates concerning the supply of engineering graduates for not only 1953 but other years in which classes now in college will graduate. Line 1 shows the number of bachelor's degrees estimated by Dr. Armsby of the Office of Education. The remaining figures use those numbers as a base, on the assumption that the number of men with graduate training becoming available will be roughly equal to the number of seniors entering upon such training. The notes on the table itself explain the methods used in making the estimates given. It is recognized that the actual situation will vary, possibly substantially, from that shown. Some of the men eligible for the draft or in the reserves will not enter military service, at least not immediately upon graduation. Not all of those who entered two years earlier will return, but within reasonable limits, some changes in one element of this picture will offset changes in another, and the final totals shown in Line 6 should be generally representative of the situation, assuming that announced policies concerning the drafting of men who have received student deferments are to continue. If they do not, the numbers available to industry in 1955 and 1956 will increase, perhaps substantially.

Demand vs. Supply 1953–1956

It seems clear that the shortage experienced last year will continue in 1953. There is some likelihood that the total demand may decrease in the next few years as the defense build-up activity tapers off, but these data would indicate that a substantial shortage will continue.

Possible Long-Term Situation

Any estimate of demand beyond the next few years is likely to be speculative. In 1951, the Bureau of Labor Statistics estimated a demand for not less than 30,000 during any period of partial mobilization, with a demand greater than that during the build-up period. It would be difficult to suggest any better figure today.

PRELIMINARY RESULTS

Need for Engineering Graduates in 1953

From Survey by Engineering Manpower Commission of Engineers Joint Council

Character of Sample Secured

	No. of Companies	% With Less Than 1000 Employees
1952 totals	380	21%
1953 to date	242	37%

Results for Selected Industries Only *

	No. of Companies	Total Engrs. Employed, Jan. 1	Required from Current Classes	Requirements as % of Engrs. Employed
1952 totals	156	77,201	11,358	14.7%
1953 to date	108	33,635	5,189	15.4%

From Current Classes

Ratio 1953 Expected to 1952 Actual Employment	Ratio 1953 Required to 1953 Expected
92%	133%

* Manufacturing industries: Machinery except electrical; electrical machinery, equipment and supplies; transportation equipment; chemical and allied products; petroleum and allied products.

Supply of Engineering Graduates

1953–1956

	Graduating Classes			
	1953	1954	1955	1956
1. Graduates	24,000	19,000	23,000	30,000
2. ROTC Commissions[a]	4,500	5,500	8,100	8,800
3. Draft eligible and Other Reserves[b]	7,200	7,100	9,900	14,100
4. Net for Industry, Education, and Civilian Government[c]	12,300	6,400	5,000	7,100
5. Returnees—Recent Graduates[d]	14,000	12,000	11,700	12,600
6. Totals for Industry, etc.	26,300	18,400	16,700	19,700

[a] Current Dept of Defense objectives.

[b] 1953—Engineering Manpower Commission Survey. 1954–6—Remainder after deduction of ROTC, veterans, and 4 F.

[c] 1953—derived directly from Lines 2 and 3; about ⅔ pre-Korea veterans and ⅓ 4 F. 1954–6—4 F (⅓ of non-ROTC and non-veterans)—veterans in 1954 only (15% of class).

[d] ROTC and draft eligibles 2 years previously.

As to future engineering classes, Dr. Armsby has recently studied this situation carefully and on the assumption that the proportion of the total freshman class enrolled in engineering in the fall of 1952 was somewhat greater than normal, he estimated a modest decrease from the 1956 figure of 30,000 followed by a graduate rise to at least that figure by about 1961. If the conditions which led to a large freshman class last fall continue, it is quite likely that no dip will occur and there will be a gradual and continuous rise.

DONALD S. BRIDGMAN, *Chairman*
June 22, 1953

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Reprints Available . . .

Are you interested in receiving copies of the newly completed "Manual of Graduate Study" or the "Report of the Committee on the Improvement of Teaching"? Copies of these can be obtained from the Secretary's Office, the price of the Graduate Manual being 50¢ and that of the Report of the Committee on the Improvement of Teaching being 15¢ each or $8.00 per hundred. All orders should be accompanied by a check remittance.

Do You Know—

► A grant of $30,000 to the ASEE has been authorized by the Carnegie Corporation of New York for a comprehensive investigation of the Humanistic-Social Studies in the engineering curriculum. The Humanistic-Social Division of ASEE, under the Chairmanship of Professor Sterling Olmsted, prepared the proposal which contemplates a two-year comprehensive investigation of the subject matter organization and teaching methods in the social sciences and humanities courses for engineers. This project will appraise the present status of these programs and identify those programs which appear to be well-conceived and have considerable merit. It will prepare recommendations for improvement of this area of instruction. The project will be directed by Professor George A. Gullette, Head of the Department of Social Studies, North Carolina State College. He will be assisted by an Advisory Committee consisting of a number of leading authorities in the field. The project will be launched just ten years after the Hammond Report, which advocated careful attention to this area of instruction.

► Plans for the two Summer Institutes to be held in the Summer of 1954 are progressing satisfactorily. One of these will deal with the influence of solid state physics upon engineering and engineering education, the other will deal with nuclear science in engineering. These conferences will endeavor to obtain an orderly and systematic organization of the fundamental concepts in these fields for teaching purposes. Each conference will consist of a closed meeting of a number of leading research scientists and engineers to conduct a preliminary exploration of the subject matter. This will be followed by conferences open to a limited number of ASEE members in the Summer of 1954. The Solid State Physics Closed Conference will be held at the University of Illinois and the open conference at Carnegie Institute. The Nuclear Science Closed Conference will be held at Columbia University and the open conference at Northwestern University.

► The YET movement in the Society has gained great momentum as a consequence of steps taken by the Divisions and Sections of the Society to bring young teachers into active participation. This can be a highly significant development which will greatly enrich the professional competence and broaden the outlook of young teachers. A number of colleges have established YET committees among their faculty members. They attest to the vigor and enthusiasm which young teachers have displayed in this movement. It provides a pleasant social experience and a means of growing professionally by active participation. Professor Robert T. Howe of the University of Cincinnati is Chairman of the YET Committee.

► The preliminary report of the ASEE Committee on Evaluation of Engineering Education has been sent to committees in all of the participating engineering colleges throughout the country and also to deans of engineering colleges. Comments and recommendations are invited. These should be sent to Professor Dan Pletta at Virginia Polytechnic Institute, who is Secretary of the Committee. A summary of the Report appears in the November, 1953 issue of the Journal. The Revised Report of the Committee will be drafted shortly after the first of February.

► Again may we remind you of the six summer schools to be sponsored by ASEE this year. This is the largest number of

summer schools ever sponsored in any one year. These include summer schools in:

a. Machine Design, sponsored by the Mechanical Engineering Division;
b. Graduate Studies in Engineering Mechanics, sponsored by the Engineering Mechanics Division;
c. Humanistic-Social Studies;
d. Engineering Economics;
e. Electrical Engineering;
f. A summer school sponsored jointly by the ASEE Division of Educational Methods and the General Electric Company.

► The Local Committee at the University of Illinois is busy planning facilities and entertainment for the Annual Meeting this year. Professor Lisle Rose, Chairman of the Local Committee, and incidentally also Chairman of the ASEE Public Relations Committee, is doing an excellent job on both fronts. He recently underwent an operation and is convalescing. We send him our best wishes for a speedy recovery.

► If you wish to submit nominations for either the Lamme Award or the George Westinghouse Award, you can obtain brochures describing the awards from the Secretary of the Society. The final date for submission for nominations is February 1, 1954.

► Again may we remind young teachers of the YET Paper Contest this year. The rules were published in the October and November issues of the Journal.

► The ECRC is preparing a policy statement as to why an engineering school should have departments of research, experiment stations, or research institutes. This will be presented for consideration by the ECRC at the Annual Meeting.

Vice President Walker also reports that the ECRC is preparing a survey on the financial policies of research in engineering colleges to determine the practices regarding overtime work, extra pay, and division of teaching and research loads.

► The Committee on Constitution and By-Laws is preparing a final draft of the proposal for an increase in Society dues. The proposal is to establish dues ceilings of $10.00 for members 36 years of age or over and $7.00 for members under 36 years of age. The dues for the first year after adoption of the amendment would be $8.00 for those over 36 years of age and $6.00 for members under 36 years of age. There will also be a provision that the dues are not to be increased by more than $1.00 per year after the first year.

Since 1946, the Cost of Living Index has approximately doubled. There is no way the Society can avoid these rising costs. Until last year, the Society maintained a balanced budget by rapidly expanding its membership and seeking increased advertising in the Journal. But these activities in themselves have entailed increased operating costs.

► It is with regret that we note the passing of Dean Harry P. Hammond. Dean Hammond was one of the truly great leaders of engineering education. He was always a quiet and humble individual, but his influence was both deep and profound. He worked with Dr. Wickenden in the preparation of the "Report of the Investigation of Engineering Education" and was one of the principal individuals involved in each of the subsequent reports, "Aims and Scope of Engineering Education" and "Report of Investigation of Engineering Education After the War." It is not often that a man of his depth of vision and insight comes along. The Society has been indeed fortunate to claim him as a leader and friend.

► The October and November issues of the Journal were a little delayed owing to last minute changes in material to be published. We should be back on schedule with the January and subsequent issues of the Journal.

Our best wishes for a Happy and Prosperous New Year.

ARTHUR BRONWELL, *Secretary*

On Engineering Integrity

By THE COMMITTEE ON THE PROMOTION OF ETHICAL STANDARDS, AMERICAN SOCIETY FOR ENGINEERING EDUCATION

In June, 1952, the General Council expressed concern about the condition of ethics in the engineering profession, and especially concerning instruction in ethics in the colleges of engineering. The president appointed a committee to investigate the matter, and the committee has since been constituted into a standing committee of the Society. The committee has submitted the following preliminary statement which is designed to be a basis for its future projects. In order that the work of the committee shall be adjusted to the viewpoints of engineering educators and members of the Society, all are urgently requested carefully to read this statement and to send written comments to the Editor.

Are engineers getting careless about their ethics? Are they willing to "cut the corners"? Are they beginning to sacrifice "just a little" honor to gain dollars? An outright answer is neither easy nor, perhaps, possible.

For one thing, does the question refer only to the accepted standards of decent conduct which should govern all men, regardless of their state in life, whether engineers, physicians, merchants or mechanics? Or does the question likewise refer to the codes of engineering ethics, such as those published by the Engineers' Council for Professional Development, and by the Founder and others of the older engineering societies?

Again, judgment in the matter should possibly be qualified because engineers are expanding their activities so rapidly. The engineer of a hundred years ago performed comparatively simple tasks. He designed, and supervised the building of harbors, canals and railroads. But during the past twenty or thirty years, engineers have introduced their power and their devices into factories, homes, schools; and into every city, town and village in the civilized world. Is it fair to judge engineers quite as severely as some other profession whose responsibilities have changed little in a century or two?

Further, the objective standards of morality remain fixed, but what people call good deportment today may differ from what they called good deportment in 1910. Men's interpretation of the moral code is severe and lax through successive cycles. Many thoughtful people feel that public scandals, bribery, self-seeking and juvenile delinquency mean that interpretation of the moral code is on the down grade at the moment. If this is so, shall we be content if the integrity of engineers disintegrates no faster than the common rate of disintegration? Or shall the engineering profession be judged strictly according to objective, permanent moral standards?

Finally, shall engineers be held responsible for the way men use their machines and structures? For instance, it is obvious that the automobile is a direct or an indirect instrument in very many crimes. Shall automotive engineers merely shrug their shoulders and remark, "We can't help it if the people don't make proper use of the cars we give them"? Or must they assume at least a portion of the responsibility for criminal use of automobiles? These are some of the reasons why it is not easy to say whether or not the integrity of engineers is deteriorating.

Because this problem of engineering integrity is so involved, the Committee did

not think that the question could be adequately investigated by any kind of formal research, or by means of the more or less despised questionnaire. Hence, the Committee wrote to engineering educators, prominent engineers, and others who are in a position to see what is going on in the community. The Committee requested the correspondents to express their viewpoints about the integrity of engineers.

The correspondents replied as follows:

	Engineering ethics holding up well	Ethics deteriorating	Some misgivings	No comment
Editors, publishers of metropolitan American newspapers	8	0	1	1
Editors, national general magazines	1	0	0	4
Editors, technical journals	4	0	0	0
Presidents, officials, industrial corporations, mostly nationally known	23	0	4	4
Presidents, secretaries, national engineering societies	10	4	0	1
Engineering educators	19	8	0	5

Most of the correspondents clearly had in mind only general moral standards, and gave no thought to formal, professional codes. But some of the presidents and secretaries of the national engineering societies seemed to orient their replies at least in part to the codes of ECPD or of their own societies.

A casual survey of this kind obviously cannot be conclusive. But the correspondence seems to indicate that it is principally the engineering educators and the officers of the national societies who are worried about the ethics of engineers. In fact, a number of non-engineering correspondents went out of their way to commend engineers for their high moral standards and deportment.

Individual Comment

A number of correspondents made interesting comments.

Several pointed out that engineers are not as severely tempted as other professionals because they work mainly with the materials and forces of nature, and the laws of nature simply cannot be tampered with.

A manufacturer, an airline official and a prominent engineering dean agree that the integrity of engineers is above reproach, but they find a general weakening of the moral fibre, a seeking for easy living, not only among engineers, but in the whole community. The dean wrote:

> I find that there is a very strong tendency to seek security, for example, at somebody else's expense, when we all should realize that the only real security is a man's value to the community.

One important manufacturer said that

> It seems to me that there is evidence of a reawakening of spiritual values in this country, and a consequent rise in our ethical and moral standards. . . . I am optimistic enough to believe that increasingly we, as a people, will find wisdom and fortitude to meet them (responsibilities) effectively.

On the other hand, another engineering dean struck a note of pessimism:

> I do not think that the integrity of engineers is deteriorating any faster than the mass of American people who have been cut loose from their religious moorings and are drifting on a sea of secularism without a moral rudder or compass.

A third dean joins him and feels that

Apparently the young graduates go out with a reasonable standard but they soon find that the consulting engineers and contractors with whom they work are frequently, if not regularly, contributing for political favors. As a result of this, their ideals become converted to the "practical approach" which leads to dishonest practice.

A respected engineer with eighteen years' experience in a certain field of industry contends that he has direct and personal knowledge of many cases of "contributions," "funds," "cooperation," "arrangements," and "kick-backs." He reports that such practices are common in municipal, state and federal projects or undertakings.

Engineers who pretend to be informed acknowledge that bribery and dishonesty are not unusual in this same field of industry. But they insist that the professional engineers engaged in this field have consistently succeeded in preserving their own integrity.

Two divisions of ASEE devoted a portion or all of one joint session at Dartmouth College in June, 1952, to a discussion of this very field of industry and its ethical problems.

More gratifying is the comment from both the president of an important automobile manufacturing corporation and the president of a strong labor union. They say that the state of engineering integrity cannot be too bad when the engineering educators are worried enough about it to appoint a committee.

The Committee believes that the situation can be appraised about as follows:

1. The great majority of engineers are ethical.
2. A small minority of engineers are engaged in a certain field of industry in which corruption seems to be common. To say the least, these engineers must be subject to serious temptation.
3. The American people regard engineers as highly ethical.

Responsibilities of the Colleges

What are the responsibilities of the engineering college faculties? This is doubtless the key question in the entire discussion. Do engineering educators have to turn out students with sound moral judgment? Or can the engineering teacher excuse himself and remark, "Engineering is applied science. My job is to teach heat transfer (for example) and how to make the knowledge of heat transfer useful in business. Let the parents, the churches, and the schools train the boys to behave themselves. That is none of my business." It does appear that the engineering colleges are responsible for showing students the difference between right and wrong. If some of the students have learned it elsewhere, well and good. It is equally the responsibility of the colleges to demand ethical conduct of their students.

The colleges prepare young men for the engineering profession. They do not pretend to make professional engineers of the students. But they do pretend so to condition the students that they can learn to become professional by means of practice and experience, or in part by advanced study in the graduate schools. Moral judgment is one of the qualifications a young man should possess when he stows away his diploma and rolls up his sleeves to go to work in plant or office; or in the graduate school.

In the Report of Investigation of Engineering Education, Dr. William E. Wickenden, distinguished spokesman for engineering education, declared that one of the attributes of "group professional life" is

A standard of conduct in relation to clients, colleagues and the public, based on courtesy, honor and ethics.[1]

After graduation the engineer learns to do engineering work: estimating, development, selling. People then expect him to use ethical judgment. Nobody will have the time or the patience to teach him what

[1] II, Part 1, 1108.

he should have learned long ago. If he can't tell right from wrong it may very soon go hard with him.

The engineering faculties must teach ethics, specifically. In spite of some opinion to the contrary, understanding of ethics does not follow from understanding of science and technology. A brilliant student of physics or refrigeration may be a crook. As Mr. T. E. Murray stated in "Some Limitations of Science,"

> Science cannot save men from themselves any more than society can. Rather it is individual men who must save society and themselves. If they will not live by virtue, they have to die by power.[2]

Aims and Scope of Engineering Education

American engineering educators have committed themselves to the teaching of ethics. In June, 1940, The Committee on Aims and Scope of Engineering Curricula presented its report to the Society in its annual meeting at the University of California. The Society approved and adopted the report. Engineering educators treasure this report as an admirable statement of their duties, ideals and aspirations.

In this report the committee states that one objective of engineering education is

> Development of moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.[3]

Engineering educators have thus accepted the obligation to teach their students ethical judgment. If they desire relief from this responsibility, they must first repudiate the report of the Committee on Aims and Scope of Engineering Education. They have no other choice.

Moreover, if the colleges decline to instruct students in ethics, who is going to tell them about the ethical codes of the profession? Where will they learn about the Canons of ECPD, and the special codes of the Founder and other societies?

Let us grant, for the sake of argument, that parents, school teachers and pastors should train boys to be upright before they ever register as college freshmen. But how can parents, teachers and pastors inform boys about professional codes? And whom are they to inform? How can they know which boys will become engineers? If the young engineer is to learn about the professional codes it will clearly have to be in his college.

Of course, the teaching of ethics is not the exclusive task of the colleges, except for the professional codes. Training young men to be upright is a continuing task. Parents should begin the job, school teachers and pastors should carry it on, and the college faculties should complete it.

Whether integrity among engineers is improving or deteriorating really has no bearing upon the responsibilities of engineering educators. It is their task to instruct students in ethics and to require students to be ethical in their deportment. If integrity is improving the educator may be entitled to some little gratification. If integrity is deteriorating he must redouble his efforts. In no case may he relax.

Authority and Criteria for Ethics

If engineering educators are to teach ethics, they must know two things: What are the rules or standards of ethics; and by what authority have they been established and promulgated?

These two questions have to do only with general ethics. They do not pertain to the Canons or codes of professional engineering ethics. Nor is the Committee concerned with the whole system of morality. The Committee obviously has nothing to do with burglary, arson or homicide. The Committee is concerned rather that engineers shall strictly and delicately regard the personality and the well-being of those whom they encounter in their work. The Committee is further con-

[2] *Electrical Engineering*, LXXIV (February, 1952), 125.

[3] *Journal of Engineering Education, XXX* (March, 1940), 564.

cerned that engineers shall be intellectually honest, that they shall be generously loyal to the institutions with which they are associated, and that they shall otherwise live up to superior standards of conduct and attitude.

Fortunately, persons of superior education and background, engineers and others, very largely agree upon what is right conduct and what is not. Cultivated and refined men spontaneously approve an act that is generous, and condemn an act that is mean or dishonest. It is a matter of conscience. But conscience is not the exclusive prerogative of the elite. All men spontaneously judge right from wrong. Every man praises and blames over and over every day, and every time he does either, he voices a decision of his conscience.

Most engineers agree as to what is good conduct and what is not. But neither engineers nor others seem to agree about the criteria or the authority for ethics: "The rules seem right to me but where did they come from? Who put them together? What right has he, whoever he was, to tell me what I am to do and what I can't do?" The question is important. If there is no authority, no criterion, men who incline to evil may revise the rules at any time, so that vice shall no longer be vicious. There must be criteria for reference.

Men who are interested have recognized various criteria or authorities, very often with deep conviction and enthusiasm. Some of these criteria or authorities are the following:

Feeling

Feeling means different things to different people. The erratic impulses of an emotional person can hardly be a safe norm of good deportment. The impulses of a mob are a dangerous guide of conduct. On the other hand, the decisions of conscience are called feelings by some people, although many reputable philosophers contend that they are intuitive intellectual judgments. This much is certain, the moral judgments of a responsible man are consistent; they conform to a pattern, whether they result from feeling or from judgment.

Good Taste

There are cultivated and refined men and women who deport themselves ethically, but apparently decline to recognize any moral authority whatever. They are not sure about right or wrong, but they adhere to a code of good taste, "the thing to do." Their standard of good conduct is that which is approved by the "best people." Their standard of evil conduct is that which is vulgar or offensive. By good deportment they practically mean good manners, and by an upright man they mean a gentleman.

Scientific Research

The methods of the physical sciences have been eminently successful in their proper field. These methods have acquired impressive prestige from their success. As a result it has become the fashion to insist that everything men do must be subjected to and governed by research, and to hold that there is no truth except the "facts" which are established by laboratory type experiment. Those who hold to this opinion give to prevailing moral standards only tentative support, against such time as scientific investigators shall evolve a new system of morality. However widely held and respectable, this approach seems to be at least open to question. As Dean Hugh Taylor of the Graduate School of Princeton University has explained, the

> . . . sciences provide answers as to observed behavior; but they do not answer the question whether such behavior is right or wrong. The whole area of ethical judgments or conclusions lies outside the province of these sciences. They cannot answer the question: should I do this? Ought I to do that?[4]

[4] *Religious Perspectives of College Teaching in the Physical Sciences.* P. 25. *New Haven: The Edward W. Hazen Foundation, undated.*

Golden Rule

Very many people refer all their problems and perplexities of deportment to the Golden Rule: "Do unto others as you would that they do unto you." Generous and high-minded men have thought the question through and find the Golden Rule best suited to their outlooks and temperaments. Others are too busy (or too lazy) to think about the question at all, and instinctively feel that the Golden Rule cannot lead them astray. The Golden Rule is doubtless a satisfactory basis of morality for those who are unaffected and kindly, and eager to "be right."

Natural Law

The natural law is a logical basis for ethics and morality. Philosophers of the Western world have studied and observed the nature of man. From their study and observation they have evolved the natural law to meet the intrinsic needs of human nature, and to perfect the character of man, both as an individual and as a member of his community. Natural law requires people to be virtuous: honest, just, temperate. Natural law is the foundation of the systems of positive and civil law.

But only the expert, and perhaps not even he, can readily understand the natural law. It is not easy to interpret Aristotle, Cicero, the Stoics, Augustine, Thomas Aquinas and others who have proclaimed the natural law. It is so difficult indeed that there seems to be no concise, practical moral code which the ordinary citizen can grasp and obey, and which has been derived exclusively from the natural law. Of course, highly intelligent and thoughtful individuals may study the natural law and construct their own moral codes. The chairman of the board of an important automobile manufacturing corporation wrote the Committee that engineers

> . . . must realize that proper moral judgments cannot be made without wisdom; and wisdom imparted by a knowledge and love of God, and by a thorough grounding in the humanities of the great Western tradition. It is from these sources that guidance must always come.

This chairman undoubtedly knows something about the natural law.

Tradition

Many persons feel they are on safe ground when they conform to the viewpoints of the leading thinkers over centuries of time. "If all respected people, or nearly all, agree about something, and always have, they can't be far wrong." The peoples of the Western world have adhered to a consistent standard of ethics during nearly twenty successive centuries. This consistent standard is based on the natural law. Mr. Winston Churchill meant this Western tradition of ethics when, at the Massachusetts Institute of Technology in 1949, he spoke of

> . . . our inheritance of well-founded, slowly conceived codes of honor, morals and manners, the passionate convictions which so many hundreds of millions share together of the principles of freedom and justice . . .

Religion

Religion may well be the strongest motive for right conduct. All religions of the Judaeo-Christian system prescribe the Ten Commandments. There are people, of course, who deport themselves correctly, without subscribing to any form of religion. But if the experience of centuries means anything, the great majority of religious persons can be depended upon to be ethical. To worship the Creator, and to have a high regard for one's fellow man as the likeness of the Creator, seem to have inspired most of the personages whom history recognizes as especially high minded and ethical. Men who have all their lives been active members of religious denominations invariably and justly are expected to be upright in their dealings with fellow citizens. In fact, this is so much the case that it is considered especially disgraceful when a church mem-

ber fails to live up to accepted ethical standards. By the practice of religion are here meant reverent and sincere religious observances, not merely to go to church as a social gesture or custom.

Review

When a man deports himself in such a manner as to win the approval and respect of all who know him, it may be all but offensive to raise a question about the criteria or authorities which sustain his code of ethics. However, an acceptable code of ethics may derive from a faulty premise. Hence, it appears to be the Committee's duty to review the criteria and authorities for morality which have been enumerated and discussed, and to make proposals regarding them.

As a criterion or authority for universal systems of morality, the Committee is of the opinion that:

1. Feeling is unreliable because essentially unstable.
2. Good taste is too closely related to good manners, which vary from region to region and from decade to decade.
3. The research methods of the physical sciences are not adequate to the determination of moral right and wrong.
4. The Golden Rule is satisfactory, although selfish men will reject it.
5. The natural law is a sound basis for morality. Its only, but serious handicap is that it is difficult to interpret.
6. Tradition and history of the Western world are acceptable since they represent an exceedingly wide range of human experience.
7. Religion is likewise a sound basis for morality. But its handicap is that too many of the people do not practice religion; and too many more do not recognize religion as a guide to conduct.

Accordingly, it seems clear that any general system of ethics must rest upon more than one criterion or authority.

Instruction in Professional Ethics

Students need to learn two phases of ethics: special ethics, which pertains to the status and the practice of professional engineers, and general ethics, which governs the deportment of all people, regardless of occupation or condition. The two are quite distinct although they have many maxims in common.

The obligation of the faculties to instruct students in professional ethics is probably more serious than the obligation to instruct them in general ethics. After all, the teaching of general ethics is a joint responsibility which the faculties share with parents, school teachers and pastors. But there is nobody with whom the faculties can share responsibility for teaching professional ethics.

Instruction in professional ethics should be considerably easier than instruction in general ethics. For one thing, criteria and authority for professional ethics are clear. It is obvious that the professional engineering societies constructed the codes for guidance and control of their members. There can be no question about their authority to do so. The Canons of ECPD are principally, if not entirely, an adaptation to the entire profession of existing codes of the several engineering societies.

Furthermore, basic subject matter for the teaching of professional ethics is no problem. The Canons of ECPD and the codes of the Founder and other societies are available. However, as far as the engineering teacher is concerned, these are no more than outlines. As they stand, undergraduate students could hardly understand them. The Canons of ECPD, for instance, are expressed in general and abstract language. So it is that the professor who stood before his class and recited all the twenty-eight Canons would face only bewildered young men when he concluded. An inexperienced undergraduate who read the Canons, even carefully, would not be much enlightened. The teacher must interpret the Canons to give them meaning, and he must state the

meaning in simpler if more abundant language. There seems to be no prepared text or manual for this purpose.

Neither can the teacher find an adequate supply of cases or other material to illustrate the several Canons. Competent authorities feel that subject matter such as professional ethics is best taught by means of incidents which illustrate violations and graphically describe the harmful results of those violations. Such material might quite easily be assembled. For example, without disclosing names, any state board of engineering examiners could supply accounts of the violations of ethical codes which have been brought before it. Committees on ethics, professional status or responsibility of the Founder and other societies could submit records of cases which they have reviewed. Some years ago the late Professor Daniel Mead conducted a monthly feature in Civil Engineering in which he proposed solutions for troublesome ethical problems. So much for professional ethics.

Instruction in General Ethics

Instruction in general ethics is rather more difficult than instruction in professional ethics. First of all, engineering students may not be much interested in general ethics. In spite of many exceptions, they notoriously take little interest in subject matter not clearly related to the purely technical phase of engineering. Their habits of thinking and working have got them used to steel, steam, gas and concrete. They incline to be uncomfortable when such topics as responsibility, human relations, judgment and aspiration are thrust upon them. Abstractions irritate them. Furthermore, there is a variety of criteria or authorities for general ethics. This variety may confuse the students, or make them skeptical, especially if champions of the several criteria insist that none except their own are valid. The teacher will find it hard to explain that a single and an adequate system of morality can originate from any one of several premises, or even jointly from a number of them. The teacher will find it still harder to persuade students, especially intelligent students, to accept any system of ethics as a set of regulations without explaining the sources from which those regulations derive.

Several criteria or authorities for general ethics may be confusing, but, on the other hand, they may reinforce the teaching. Thoughtful students should be impressed by the circumstance that divergent philosophies may produce largely identical, practical systems of morality. Knowledge appears more secure when it originates from more than one independent source.

As far as the Committee could ascertain, there is no text in general ethics which is suitable for all colleges of engineering. There are texts in ethics, of course, but they are apparently designed for students who specialize in ethics or philosophy, and such texts are not adapted to engineering students.

Instruction in general ethics will require even more illustrations and incidents than instruction in professional ethics. The student readily understands the professional codes because they relate directly to his chosen profession. But he will find general ethics more perplexing. Fortunately, there is no lack of cases for instruction in general ethics. Indeed, the instructor will find more ethics problem matter in the current newspapers than he can ever use.

The Committee wishes to call attention to a weakness in the case method as it is sometimes used. The method is quite in fashion. Whenever a method is fashionable, too many teachers adopt it enthusiastically without knowing how to use it. Hence, there is a tendency to discuss cases as human interest stories without relating them to the criteria involved.

Instructional Procedures

The question now arises, how is an engineering faculty going to instruct students

in ethics? The obligation to do so is clear, but how is it to be carried out? By means of formal, credit courses, by lectures, by honor systems, or merely by maintaining in the college an atmosphere of honor and integrity?

The easiest offhand answer is to offer credit courses in ethics. But such are not favored in all quarters. The president of an important technical institution, an eminent scientist, expressed astonishment at the mere mention of a course in ethics. Other correspondents share his view. Their attitude is in good repute. Most Americans feel that, however forceful and precise our indoctrination of students in mathematics or physics, or even in democracy or free enterprise, we must never give them positive direction in any matter pertaining to personal deportment.

Others hold to the opposite view: "And why not a course? The only way I know for students to learn a subject like ethics is for somebody to teach it to them, and the more emphatically the better. I don't expect the students to learn structures by themselves, so why should I expect them to learn ethics by themselves? It has to be a credit course. If we give no credit, we practically tell the students that we consider ethics of no consequence."

A few college faculties are convinced that lectures are the best way to teach ethics. Indeed, lectures on professional subjects have long been a feature in a number of colleges and schools of engineering, and the lectures seem to include more or less reference to ethics. These references are probably to professional codes rather than to general ethics.

An exceptional teacher may be able to make lectures effective. He must have a strong personality, and will need to be interesting and forceful; otherwise the students will go to sleep.

Courses or lectures alone, however, will never make students ethical. There has to be motivation. In his contribution to the Buck Hill Falls conference, Dr. H. S. Rogers declared that

> Within the scope of professional training and perhaps within a program of general education, time does not permit the attainment of any high level of critical or philosophical understanding of the good man and the good citizen. Many examples, furthermore, of immoral and unsocial conduct on the part of the Nazis, Fascists and Communists, well informed in history, can be used to illustrate the gaps between knowledge, beliefs and conduct.[6]

He was not speaking of ethics in particular, but his comment applies as well to ethics as to other humanistic-social subject matter.

The attitude and deportment of the engineering faculty must be faultless if the students are to take ethics seriously. The faculty must strictly observe ethical codes, and must require the students to observe them. This is so well understood that some faculties depend exclusively upon the morale and the atmosphere in the college for imparting ethical understanding. Besides, all the faculty must support the program. The professor who teaches thermodynamics at 10 o'clock must not scoff at the distinguished visitor who insisted on high moral standards in his address before the student body at 9 o'clock.

If ethics is to be taught either in courses or by means of lectures, the instructor will need to be exceptionally competent. He will be either an expert in ethics or philosophy who is interested in engineering students and education, or an engineering teacher who has made ethics a special study or hobby. He must know how to capture and retain the attention of his students, and this calls for unusual enthusiasm and inspiration. Furthermore, he will need a sense of consecration to a special mission. He will have to do the work largely for the love of it.

The instructor will probably be most successful if he proposes a system of

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[6] "Gaps Between the Statement and Achievement of Objectives in the Education of the Engineer," *Education for Professional Responsibility*, pp. 45–46.

morality to the students and then relates it back to its origins. In this kind of subject matter, he will be less effective if he follows the more logical method of working from the premises down to the system or code.

Curriculum Revision

If there is to be a credit course in ethics, where is it to be inserted into the crowded curriculum? Some other courses will need to be eliminated. However, if the faculties are fully aware of the importance of ethics, and of their obligation to teach it, they should have no serious difficulty. The Committee studied curricula as published in the bulletins or catalogs of many colleges of engineering and discovered the following courses offered in various institutions. In the opinion of the Committee, ethics might well be substituted for any one of them:

Anthropology
Background of Contemporary Civilization
Background of Democracy
Cultural Elective
Development of Western Civilization
Human Engineering
Industry and the Individual
International Relations
Management and Labor Relations
Modern Civilization
Non-technical Elective
Social Science
Survey of the Humanities
United States in World Affairs

But as explained, all this applies only to those faculties who choose to teach ethics by means of formal, credit courses.

Whatever method the college uses, it is essential that the faculty bring the method to bear on all the students. The faculty is responsible for imparting to all students an understanding of ethical values. This responsibility cannot be carried out if students can be absent with impunity from whatever exercises have been prescribed, or if faculty or students are permitted to violate ethical codes.

The Committee is not yet prepared to recommend any one method in preference to others for imparting ethical understanding to students. Conditions are too different in the colleges and schools. Lectures may be feasible in one college, courses in another, and tradition in a third. Each faculty will make use of whatever special resources are available. In a well known school of engineering, "The honor system covers not only such things as unproctored examinations but also complete reliance on the honesty of students and faculty in all academic matters as well as in all campus activities. Thus, for example, personal property has always been perfectly safe anywhere on the . . . . . campus." This school clearly possesses an excellent apparatus for inculcating ethical understanding. Other institutions have strong departments of philosophy. Still others are religious foundations with influential religious atmospheres. Each must be utilized for ethical instruction.

The important matter is that the faculties take their responsibility for ethics very seriously, organize and work dutifully to meet this responsibility, and institute reliable checks to make certain that the responsibility is fully executed.

Conclusions

The Committee feels that it has completed a reasonably correct review of the condition of ethics in the engineering profession and in engineering education. The Committee was appointed only nine months ago. Obviously, the Committee has made no comprehensive or scholarly investigation, such as a company of experts and statisticians might complete in a year or two. The members of the Committee are all active in their respective positions and occupations. This statement of the Committee is the result of such careful and diligent inquiry and consideration as the members were able to accomplish in addition to their regular duties.

As a result of its study, the Committee believes that:

1. Most engineers are ethical.
2. Engineers have an excellent reputation for integrity with the general public.
3. There is a tendency among engineers, and among others in the community, to decline to accept responsibilities; which does not imply that engineers fail to carry out responsibilities which they have accepted.
4. There is evidence of a degree of corruption in a certain field of industry. While the individual engineers in this field may have maintained their integrity, they must be subject to temptation.
5. Engineers should understand and comply with both general and professional codes of ethics.
6. Standards for general ethics should derive from several criteria or authorities.
7. Criteria exist for both general and professional ethics.
8. Insufficient illustrative material is available in organized form for instruction in ethics.
9. Engineering educators are responsible for instructing students in ethics, and for motivating them to comply with ethical codes.
10. Very few colleges or schools of engineering have introduced formal or specific measures for ethical instruction.

Recommendations

The Committee proposes the following recommendations:

1. That the faculty of every college or school of engineering be concerned with instruction of all students in general and professional ethics; and with their motivation so that they will comply with ethical standards after graduation.
2. That this concern of the faculty be implemented by such specific and formal measures as may be most appropriate to the traditions, organization and operation of the individual institutions.
3. That promotion of ethical standards in engineering education be recognized as an element in the objectives of ASEE, and that a permanent organization be created, in the Society, and permanent activity undertaken, in order to achieve this objective.
4. That one such activity be the organization of subject matter and reference material for ethics instruction.

Acknowledgment

The Committee wishes to express its appreciation to officers, Council and staff of ASEE, and to many engineers, educators, engineering society officials, industrialists, editors and others. The Committee would have been helpless without their information, their viewpoints, and especially their encouragement.

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An extended bibliography has been prepared by the Committee and copies will be available to anyone who wishes to request one from the chairman.

The Echelons of Engineering Education

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The year 1952 marked the formal centennial of American Engineering. We now enter the second century of this modern technological era. Yet the grains of sand in the hour glass of eternity move very slowly indeed when compared with the rapid and complex scientific advancements of the last few decades. The science of engineering in the United States has developed from infancy to a mature position of great importance during the past one hundred years. Engineering education has played the dominant role in this phenomenal growth.

America's genius for production has been achieved by the education and utilization of large numbers of trained scientists and engineers. A democratic society providing more and more higher education for a greater number of people has made this possible. Yet engineering education is a mere neophyte compared with the older formal educational disciplines required for the learned professions. In 1870 there were but six engineering schools in this country, providing training for only three hundred graduates each year. Since then, the rapid and widespread growth of public institutions of higher learning has contributed considerably in bringing about this country's engineering and industrial accomplishments. The founding of municipal and state universities and the establishment of the widespread system of Land-Grant colleges have made possible a hundred-fold increase in engineering education in but eighty short years.

During most of this time, since 1893, engineering educators have been banded together in what is now the American Society for Engineering Education to work cooperatively and intelligently in the general interest of education. The process of educating engineers in the engineering schools of America has received a great deal of study. Generally speaking, this study is the major purpose and continuing objective of the Society. However, there have been, from time to time, specially-designated committees assembled to make up-to-the-minute reviews and recommendations for the betterment of our educational system—either through improvement in teaching, curriculum content, or facilities.

The first significant study was made in 1929 when engineering education was little more than seventy-five years old (1). At that time, Wickenden pointed out that the "higher forms of technical education have developed sporadically in the United States and without an underlying plan." He then went on to say that one type of engineerig education, viz., the four-year curriculum with lectures, recitations, and laboratories, has tended to develop to a point of domination. At the same time, there was a marked difference between the product of American schools and those graduating from the European technical colleges. Some of the difference resulted from the influence of the Land-Grant

College movement which tended to make education available to all those who could profit from it, but at the same time tended to make our American engineering education of the more practical variety. Wickenden went on further to say that European schools had found no substitute for our curriculum or our specialization, but in the teaching process we seemingly lagged far behind. "In nothing does the essential juvenility of our higher education reveal itself so fully as in the textbook, daily assignment, recitation, written quiz, piecemeal grading system of instruction, and in our eager effort to compensate for the students' defective mastery of the processes of learning by one and another pedagogic device."

Unfortunately, little if any change has taken place in this respect in the more than twenty years since Dr. Wickenden's report was published. The report further pointed out that our instruction in industrial management was more advanced than that in European schools and that much interest was being shown by many European educators in our accomplishments in this area. Most important of all, it was pointed out that our education stressed the art of engineering and not the science. Our curricula contained too many courses in drafting, shop practice, and "how to do it," and not enough in science and the fundamentals of engineering. This was emphasized by the realization that American industry, when seeking engineers who could make important contributions in the design of new and better equipment, usually looked to Europe and not to the graduates of our own engineering colleges. It was also admitted that many American universities, too, sought European scientists for the more important and better teaching positions. Obviously, something was wrong. Slowly changes were brought about by educational planning. Gradually, the art-type of courses have been dropped from our curriculum and replaced by more fundamental courses in mathematics and science. This has been fortunate since changing times and a changing world have now made it quite necessary for us to be self sufficient in preparing our creative engineering manpower.

Again, in 1939, spurred on by criticism from many industrial leaders that our engineering graduates were deficient in their use of English and by the universal realization that engineers were not assuming their proper place in industrial or civic affairs, a special committee of the Society, meeting under the chairmanship of Dean H. P. Hammond (2) reported: "First, broadening of the base of engineering education, now in process, should be continued. Its roots should extend more deeply into the social sciences and humanities as well as into the physical sciences in order to sustain a rounded educational growth which will continue into professional life." The report went on to enumerate the objectives of the "scientific-technological studies" and the "humanistic-social studies."

Profound Influence

In the main, the important recommendations in this report have been followed and have had a profound influence on the curricula of American engineering schools. There is now much evidence to show that well-rounded individuals with a command of the English language and an understanding of the world around them are being graduated from engineering colleges and further that the engineers compare favorably in this respect with the graduates of liberal arts colleges and other professional schools.

In 1944, a third major evaluation was made through the sponsorship of the ASEE, once again under the chairmanship of Dean H. P. Hammond (3). This study pointed out quite clearly that as engineering becomes more technical and dependent on a broader base of science, the curriculum ought to provide for both the students who are well qualified scientifically as well as others who could engage in less-demanding types of engineering work. This report reiterated that the

four-year curriculum should be retained with two stems—the scientific-technological and the humanistic-social. Among other things, it also recalled an important recommendation from the Wickenden-Spahr report (4) that subprofessional technical education and training be instituted in a vigorous manner.

"It has been said that the development of technical education in this country has been so preponderantly among engineering colleges that the aims, objectives, and purposes of programs of education and training at all levels—secondary, vocational, technical institute, collegiate, and postgraduate, have become confused. Of these several divisions of technical education and training, programs of technical institute type are the ones that are less adequately recognized and provided for in comparison with others in this country. Yet it is these programs that bear the closest relationship to professional engineering and should perform the most essential function auxiliary to it. This situation is unique among the great industrial nations of the world. Until the problems of training of technical institute type are solved, the aims and purposes of collegiate engineering education are bound to be obscured. For the benefit of industry and society at large as well as of the engineering profession, it is highly desirable therefore that there be widespread recognition and development of programs of technical institute type throughout the country."

"One step that appears to be essential in this connection is the provision of means of formal recognition for institutions offering programs of technical institute type and for their graduates. At present, neither the national engineering societies, nor engineer-registration boards, nor federal civil service, grant any credit in evaluating qualifications of individuals for the completion of educational programs offered by sound institutions operating in this field. The committee believes that industry and the engineering profession should give united support to measures of recognition of sound technical institute programs. These should be similar in general nature but appropriately different in details and operation to the accrediting procedures of Engineers' Council for Professional Development as to engineering colleges and to evaluation practice of state boards of engineering examiners as to individuals. The committee believes that such measures of recognition and certification would ultimately bring genuine benefit to colleges of engineering" (5).

Not a great deal has been done to implement many of the recommendations contained in the second Hammond report although a few significant steps have been taken. Some engineering educators have responded to the challenge. It is hoped that others will follow. During the past two years the faculty of the School of Engineering at The Pennsylvania State College has given consideration to the earlier important studies of engineering education and, as a result has recommended the adoption of two new educational programs. One, a four-year curriculum in Engineering Science is designed to prepare men for the more advanced scientific engineering positions or for graduate work. This curriculum is open only to the top twenty-five students of each freshman class and is decidedly an "honors" course. The other program provides two-year terminal curricula intended to prepare engineering associates or technical assistants. These curricula require less mathematics than the conventional four-year curriculum and treat the subject matter more from the "how to do it" point of view. In the Land-Grant philosophy of providing scientific instruction to as many persons as might profit from it at relatively low cost and close to home, the two-year courses will be conducted only at the Penn State off-campus centers in the larger industrial communities in the State.

For more than forty years the School of Engineering at Penn State, through its Extension Division, has been providing a great many practical courses for industrial workers. During that time, evening technical schools have been operated continuously in a number of communities. Since 1947, day technical institute programs of one year's duration have been conducted in a half-dozen off-

campus centers in industrial areas. Careful analysis of the results attained from the School's past and existing Extension programs and study of the curricula offered by other institutions engaged in terminal tertiary education enabled a faculty committee of the School to develop two new two-year technical curricula. To best serve Pennsylvania industries, programs in Electrical Technology and Drafting and Design Technology were created.

After preliminary consideration had been given to problems of curriculum construction, the engineering faculty committee met with two groups of industrial employers. The first of these advisory committees had representation from most of the larger electrical manufacturing concerns as well as important electric

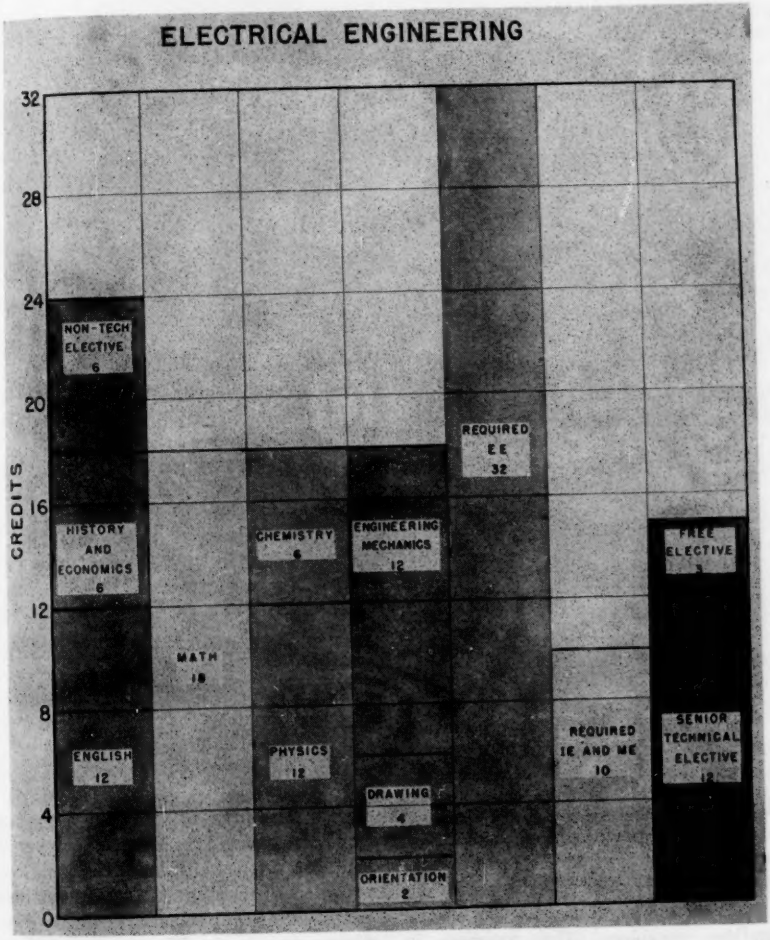

FIG. 1. The Electrical Engineering Curriculum by credits in major fields of study.

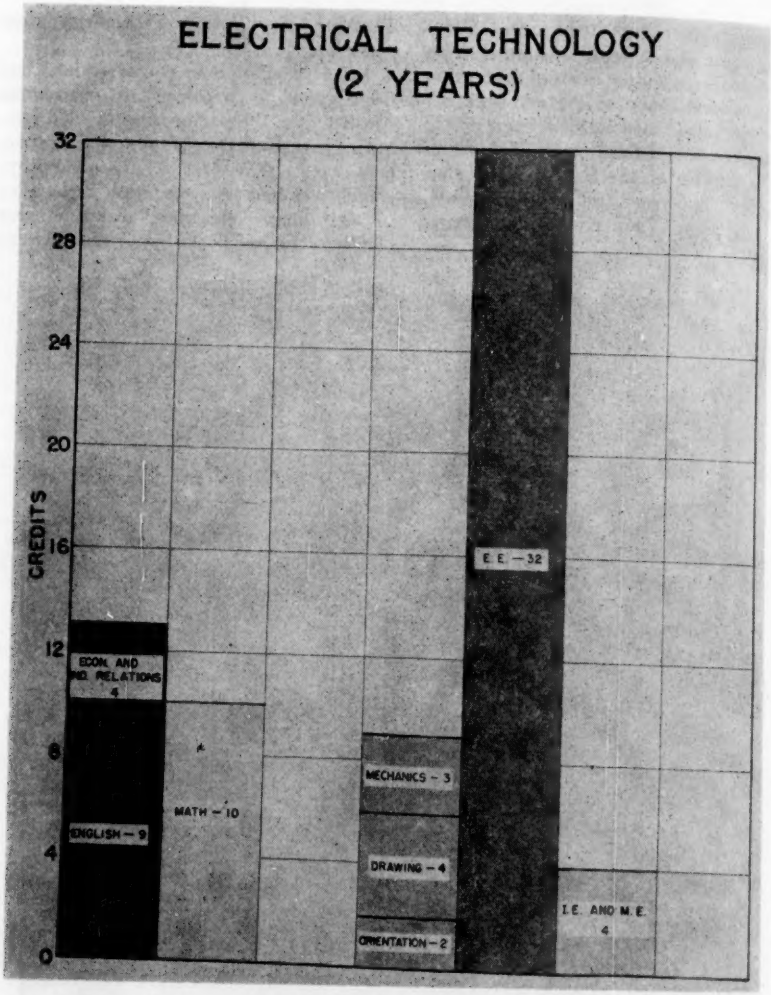

FIG. 2. The Electrical Technology curriculum showing distribution of two years of credit work.

utilities and transportation systems. They evaluated the proposed curriculum in Electrical Technology in the light of current industrial practices and made numerous valuable suggestions. The second committee considered the program in Drafting and Design Technology. This group, consisting of chief engineers and chief draftsmen from various types of manufacturing and fabricating industries, provided a direct first-hand opinion concerning the requirements for drafting and design personnel. The two curricula as finally adopted are in every sense tech-

nical institute in character as defined by Engineers' Council for Professional Development.

The two-year programs consist of courses that might fall into the following five categories: mathematics and basic science; the technical specialty; related technical subjects; English and speech; humanistic-social subjects. In this respect they are comparable somewhat in general composition to conventional engineering programs. An interesting comparison can be made, however, between Penn State's Electrical Engineering curriculum and the two-year Electrical Technology program.

In the Electrical Engineering curriculum (see Fig. 1) fifty credits are devoted to courses in mathematics and basic science. This represents thirty-seven per cent of the entire curriculum. By contrast, in Electrical Technology (see Fig. 2) only fifteen credits of mathematics and science are required, this being twenty-two per cent of the two-year program. Forty-one credits in electrical subjects are taken by Electrical Engineering students. The terminal program has thirty-two credits in electrical courses. Only thirty per cent of the Electrical Engineering curriculum is in electrical courses whereas forty-seven per cent of Electrical Technology is devoted to the technical specialty. Seventeen credits or thirteen per cent of the engineering curriculum are in related technical subjects giving the engineer breadth of understanding while only six credits or nine per cent of the technology program is so spent. Electrical Engineering students take twelve credits in English and speech and fifteen credits in other social-humanistic courses. The two-year curriculum requires nine credits in English and speech and six additional credits in social-humanistic work.

Unique Aims

These important differences in curriculum content reflect the unique aims and objectives of the two-year terminal program. It is intended to be more specific in purpose and not require a broad understanding and application of higher mathematics and basic science. It is designed to prepare the engineering associate to assume many routine engineering assignments and become an important auxiliary in the modern engineering team.

There is one other important consideration that caused the Engineering School faculty to recommend the new two-year programs. During the next ten years, it is inevitable that applicants to engineering colleges will increase rapidly. In the very near future, enrollments will exceed the capacities of existing institutions. Furthermore, from past experience it is reasonable to assume that many of those who apply will not possess the intellectual capacity for professional work. The technical institute is the answer for furthering the training of those with genuine technical interests and aptitudes but limited preparation or analytical ability.

The training of engineering associates and technical aides is an important task to be faced by all engineering educators. Dean S. C. Hollister, in his presidential address (6) to the American Society for Engineering Education at Dartmouth College in June 1952, said:

> "As matters now stand, it appears that we have reached a turning point in the profession. With the percentage of the population to be made into engineers no longer on the increase, but with the amount of engineering service needed in the economic system constantly accelerating; and moreover, with the evidence of the disparity of these two situations abundantly evident before us, it now becomes clear that a complete reorganization of the profession must take place over the next few years if the engineering work of the future is to be achieved at the level demanded by our economic system."
>
> "It also becomes clear that in this gradual readjustment three major factors will have to be given special attention:
>
> 1. The training of more aides to support the engineers;

2. The change in practice of utilization of engineers by industry and other agencies employing them; and
3. The education of the engineers themselves."

Another past-president of the Society, Dean Thorndike Saville, in his presidential address (7) quoted from Oliver Wendell Holmes' "Poet at the Breakfast Table" in which the author opines that there are "one-story intellects, two-story intellects, three-story intellects with skylights. All fact collectors, who have no aim beyond their facts, are one-story men. Two-story men compare, generalize, using the labors of the fact collectors as well as their own. Three-story men idealize, imagine, predict. Their best illumination comes from above through the skylight." Dean Saville suggested that here we have those who should terminate their post high school education in two years, those who should complete a four-year engineering course, and those who should go on to post-graduate work. He continued by saying, "Let engineering education enlarge its responsibilities and take into the fold as partner, not as step-child, these lusty youngsters." He was referring to the higher institutions offering technical terminal instruction.

For the past fifty years, the School of Engineering at Penn State has devoted most of its resources to the education of "two-story intellects" while at least recognizing that there were floors above and below them. Providing for a complete program of engineering education for Pennsylvanians and Pennsylvania industries is now at hand. Two-year engineering programs will be conducted during the next academic year. At the same time, steps have also been taken to direct attention to the "skylight."

Within the past several years, a number of engineering colleges and universities have developed and made available to undergraduate students curriculums which provide training in the broad field of technical science. Thirty-one different institutions (8) now offer programs in this area of engineering physics which do not differ materially from the Penn State Engineering Science curriculum. Of the curricula now offered at these thirty-one institutions only four (9) have as yet been accredited, two of these in 1949 and two in 1951. This is indicative of the recent developing trend in engineering education to provide programs with a broader scientific foundation that will prepare graduates for research and creative development work in industry or to continue with graduate study in the same basic field.

Following a period of curriculum development and studied approval by the faculty and the Board of Trustees, the Engineering Science curriculum will be initiated in September 1953 at the sopohomore level. During the freshman year, all engineering students follow a uniform course. On the basis of this year's work, the top fifty students are invited to apply for the Science program. Following guidance interviews, twenty-five students are selected as the sophomore group.

Program is Broad

This Engineering Science curriculum is designed specifically to train students who wish to enter the fields of research and development and the other creative aspects of engineering. The program is broader than that of the specified professional curricula and the student is given work in all major engineering sciences with special emphasis on fundamentals and the relationship between the various sciences. This curriculum is more demanding than the others and is expected to be more rigorous. It is definitely an "honors course" for those possessing demonstrated superior qualities.

As shown by the charts, a comparison of the courses required for the curriculum in Engineering Science with those in Electrical Engineering indicates that the emphasis in the former is placed on mathematics and basic technical science rather than on applied courses. The total num-

ber of credits is essentially the same. On the other hand, the two-year Electrical Technology curriculum as shown has a preponderance of time devoted to applied electrical courses with a relatively limited time on mathematics and science.

No attempt has been made to indicate the specific course contents, but the comparison as shown emphasizes the difference in coverage of fundamentals of engineering and the basic sciences in the several curricula.

For those who complete the Engineering Science curriculum and desire to continue with graduate work in a specific engineering field, a minimum of required undergraduate credits would be necessary in fields such as electrical engineering or engineering mechanics; while in others, the courses which would be required to pro-

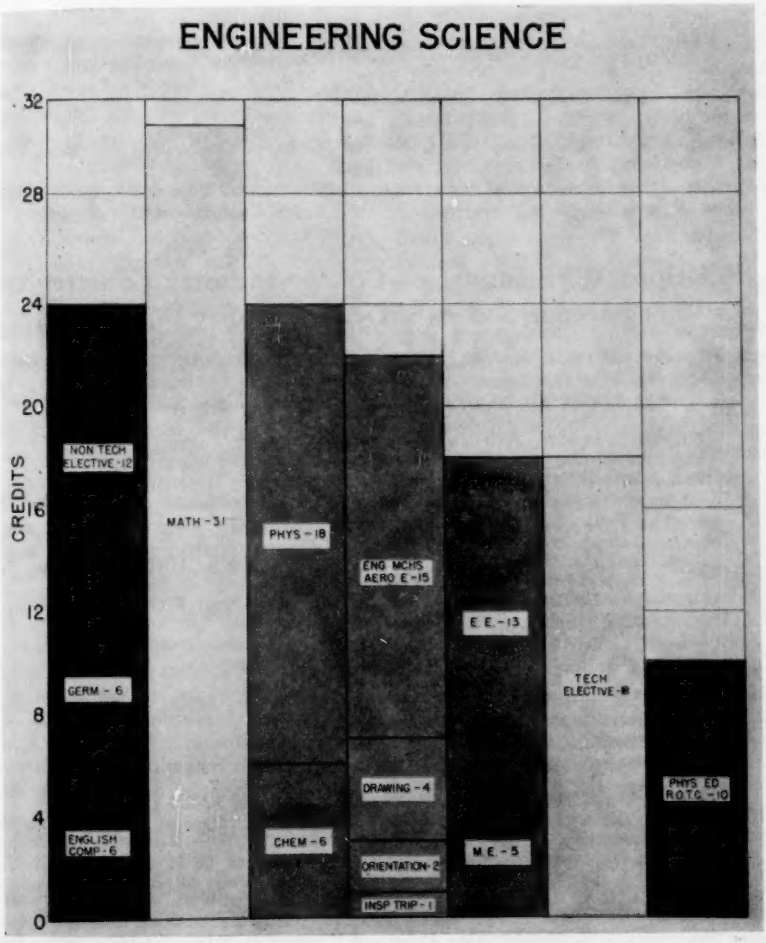

FIG. 3. The Honors curriculum in Engineering Science.

vide the proper background would be fairly numerous.

Industrial employers in Pennsylvania who have been given the opportunity to review the Engineering Science curriculum and who have knowledge of the Technology programs, have indicated their whole-hearted approval and are enthusiastic over the prospect of having an engineering institution recognize the need for educating all echelons of the contemporary "engineering team."

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Relations With Industry—College-Industry Conference

Engineering Society of Detroit, January 16, 1954

Keynote Speaker: 10:00 A.M. Col. L. F. Grant, Chairman, ECPD, Toronto, Ont., Canada.
Simultaneous Sessions: 10:45 A.M.
Ten minute talk by each speaker, followed by discussion.

A. "The Local Engineering Societies and the First Five Years."
William E. Stirton, President, ESD, Vice President, Wayne University.
Thos. A. Marshall, Jr., Executive Secretary, EJC, New York City.
Don Jahncke, Ford Motor Company, Lincoln-Mercury Division, Detroit.

B. "The Employer and the First Five Years."
Kurt O. Tech, Ch. Eng., The Cross Company, Detroit.

C. "Colleges of Engineering and First Five Years."
Dean George G. Brown, College of Engineering, Univ. of Mich., Ann Arbor, Mich.
Lee R. Baker, Director, Chrysler Institute of Engineering, Detroit.
Dr. Ralph G. Owens, Dean of Engrg., Illinois Institute of Technology, Chicago, Ill.

D. "The Individual Graduate and his First Five Years."
John J. Uicker, Assoc. Professor, Mech. Engrg., University of Detroit.
Gordon H. Millar, Research Dept., Ford Motor Company.
William Little, Cadillac Div., General Motors Corp.

Address: 1:45 P.M. to 2:00 P.M. L. E. Grinter, President, ASEE, Dean, Grad. School, University of Florida, Gainesville, Fla.

Afternoon Panel Session: 2:00 P.M. to 3:00 P.M.
(Answering questions received by mail or proposed by audience)
Dean C. J. Freund, Moderator.
Fred J. Walls, Manager, Detroit Office, International Nickel Company.
M. M. Boring, Manager, Tech. Personnel Div., General Electric Company, Schenectady, N. Y.
Kenneth A. Meade, Director of Educational Relations, G. M. Corp., Detroit, Mich.
Prof. C. Wandmacher, Head, Dept., Civil Engrg., Univ. of Cincinnati, Cincinnati, Ohio.
Rodney E. Christian, Chief Engr., Kerr Manufacturing Company.

Closing Speeches: J. J. Cronin, Vice President, Charge of Mfg., General Motors Corp., Detroit, Mich.

The National Science Foundation and Its Program*

By RALPH A. MORGEN

Program Director for Engineering, National Science Foundation

In introducing this subject to this audience, it seems unnecessary to review the history of the National Science Foundation, except to say that the Foundation is the organization which was originally envisioned by the Bush report in 1945. The present organization of the Foundation as it affects engineering and the other physical sciences has been described in a staff article in *Chemical and Engineering News*.[1]

This discussion will be confined to a quick look at what is needed for the support of engineering research in educational institutions, touching on (a) what kind of research should be done in the engineering colleges and (b) the subject of how much research should be done in the engineering colleges.

As some in this audience know, this speaker has made a study this year of the needs and desirable methods of support for research in the engineering colleges. Of the 149 institutions which have one or more ECPD accredited undergraduate curricula, replies have been received from 133 institutions. A rather more complete paper based on this study will be published later. It is interesting to note that without exception all 133 replies indicated that both "applied" and "basic" research should be conducted at engineering colleges. Naturally there was considerable disagreement on the definition of the words "basic" and "applied" and the proportions of work in the two areas would vary somewhat on the person's definition of the words. However, after unscrambling all the different definitions of the two words "applied" and "basic" there seemed to be a large majority that agreed on the fact that approximately 50% of those staff members who were engaged in research ought to be interested in basic research and the rest should be engaged in applied research at any one time as an ideal arrangement for an engineering faculty. In addition there seemed to be a rather unanimous agreement that in any given engineering faculty, only about 50% of the faculty would be interested in conducting research at all, the remainder would be interested in doing their professional work outside of teaching in fields other than research, such as writing, consulting work and other professional activities. For the first time then, there seems to be a picture of what would be desirable for the support of "basic" research in engineering colleges. Namely, if the total number of staff members in engineering colleges is known, then support for basic research is needed for approximately 25% of those staff members. The amount of support for any individual staff member will depend largely on that staff member's capacity for doing work himself, directing the work of graduate students and the type of research in which he is interested which would in turn determine the cost of equipment and supplies. This dollar phase of the program will not be pursued further. At this point

* Presented June 24, 1953, Gainesville, Florida, before The Division of Graduate Studies, ASEE Annual Meeting.

[1] *Chemical and Engineering News*, Vol. 31, p. 228, Jan. 19, 1953.

consideration will be given to the relative support among basic research, applied research, developmental work and increase of research plant.

That the support of these various types of research is out of balance is quite evident from the data given in "Balancing the Nation's Research." [2] There it was shown that in Fiscal 1952 Federal support to nonprofit corporations (of which educational institutions represent 88%) was poorly proportioned. Only 21% of the funds went for "basic" research, 50% of the funds went for "applied" research, and 29% of the funds for the support of "developmental work and increase of research plant." It is quite evident that if basic research is the primary function of educational institutions and only ⅙ of the research support by the Federal government is going to basic research, then there is an insufficient amount of funds available for basic research. Even in engineering colleges where 50% of the research should be applied research and 50% basic research, the proportion is far too low. In departments such as physics, chemistry, and mathematics, the desirable percentage of basic as opposed to applied research is 75% or more on the basic side. It is also a fact that engineering colleges are able to get more support for their "applied" programs through industrial sources then they are for the truly "basic" programs. Therefore the Federal government support should lean heavily towards the basic side.

"Basic" and "Applied" Research

At this point there is always considerable discussion as to just exactly what is meant by "basic" and "applied" research programs. At the National Science Foundation there has been an attempt to avoid discussion on the basis of the definition of these words, and to look at the program from a somewhat different point of view. The first consideration that is given to a research proposal is does it answer the following question: "If a graduate student were engaged in this particular research program is it the type of research which the graduate school of the particular university would accept for thesis purposes?" If the answer to that question is "yes," then the chances are that the National Science Foundation might be interested in considering the pursuit of that particular program somewhat further. If the answer is "no," then the National Science Foundation would not be interested in supporting the program. This gives flexibility to the program and allows the university itself to decide on the standards for research. A particular program which might be acceptable for thesis purposes by one institution conceivably would not be acceptable at some other institution. The criterion of whether or not the National Science Foundation should support that program then rests with the university. Is it acceptable to that university for thesis purposes? If so, it is probably the kind of work on which the staff and graduate students should be engaged.

After determining whether or not the research is the kind which would be acceptable to a graduate school the next question that is asked is what is the "motive" of the person who is proposing the research program. Does the principle investigator have in mind a definite or specific application for the proposed research in the form of a machine, device or specific process, or is the principle investigator primarily interested in finding out some new phenomena in nature with the probable utilitarian value either unknown or applicable to a great variety of things? If it is the former then an industrial concern, a federal agency or other organization which is interested in the application should support that particular research program. This decision has no bearing on whether or not it is considered a basic program or an applied program. The decision is based on the application.

On the other hand if there is no specific application in mind then the research might be the type which the National Sci-

[2] Ralph A. Morgen, "Industrial Laboratories," May, 1953, p. 6.

ence Foundation would be interested in supporting. Perhaps a specific example at this point will clarify the matter.

Suppose for example, that a staff member is interested in finding a material which will withstand a high temperature and is suitable for coating the afterburner on a jet engine. In order to develop such a material, a phase rule diagram must be made for a specific system of metallic oxides. The actual research on studying the melting points of a system of several oxides is conceivably basic research in many peoples' definitions. On the other hand the mere fact that this program is aimed specifically at a definite use would indicate that financial support for this program should be obtained from the agency which has primary cognizance over the development of the particular jet engine which is under consideration.

On the other hand another principal investigator is interested in the mechanism whereby films of certain materials become attached to metals and thus may act as a protective coating to that metal. In the course of the investigation that principal investigator must determine the physical properties of certain oxide systems which perchance might happen to be same oxide systems mentioned in the afterburner problem above. However, this particular investigator has no application in mind, he is just interested in the mechanism whereby films composed of oxide materials attach themselves to metallic surfaces. If the answer to that problem could be obtained there would undoubtedly be many applications in many directions. However no applications would be obvious until the mechanisms were determined. That would be a problem which the National Science Foundation might be interested in supporting.

Degrees of Motivation

Naturally there can be many degrees of motivation between the one in which a specific application is clearly and only indicated and one in which the motivation is purely intellectual curiosity. Therefore, the desirability for support for a particular program must be determined finally on the basis of the specific project in mind.

That this philosophy is in agreement with the policies of the present administration is indicated by a letter which the Honorable Joseph M. Dodge, Director of the Bureau of the Budget, wrote to Senator H. Alexander Smith, Chairman of the Committe on Labor and Public Welfare recommending that the ceiling on the research support for the National Science Foundation Act be removed. That letter stated in part "it will be desirable and economical to continue the gradual process of centralizing in the National Science Foundation the general purpose basic research for the Federal Government. * * * For this reason the enactment of S. 977 * (the removal of the ceiling from the National Science Foundation Act) would be in accord with the program of the President." It is clear from this policy statement that the spheres of influence of the National Science Foundation and the various other agencies which not only support research but have a statutory function to perform will be based on (a) whether it is general purpose research or (b) specific research rather than on whether the research is "basic" or "applied" or some other artificial definition.

How Much Research Should College Perform?

The remaining part of this discussion will be devoted to a brief look into the question of how much research an engineering college should perform. From the above it is clear that whatever research the engineering college performs, it should be balanced between applied, and basic. The specific amounts of applied and basic research will vary from institution to institution, depending on the interests of the staff and the needs of the particular locality in which the institution is located.

The other rather important question which needs clarification is the quantity of research which a particular institution

* This bill was passed Aug. 5, 1953.

should perform and thus the amount of dependence it should place on research support from sources of funds outside its usual channels of support. In other words, to be brutally frank, how much contract research should an engineering college take? Here again it is clear that no categorical or specific answer can be given which could fit all institutions. However, there appears to be a general relationship which should be maintained between the normal academic program with funds obtained for this purpose and the research program with its support obtained from more temporary or transitory sources such as a series of contracts, grants, and other forms of limited support.

It would appear therefore that if the ordinary academic budget of the engineering college or engineering division is taken as "x" then the size of the research program "y" should bear a relationship to this figure "x." The size of "y" might show large variations, but should not be allowed to vary without limit. Some relationships between "x" and "y" can be stated in rather general terms. The most important factors in determining the relationship between "x" and "y" is the size of the graduate program and the interests of the staff.

On the one extreme will be the strictly undergraduate engineering college with no graduate program. In that case there should be some research by certain members of the staff, and therefore y, the research budget should be greater than 0 and less than 0.25x. It would usually be undesirable to start a graduate program of any sort until a point were reached where the research program y was of the order of magnitude of at least 0.25x, the ordinary academic budget. With a rather substantial master's degree program and little or no doctoral level work at the institution then y might vary from 0.25x to 0.5x.

When the research program has developed to the point where y is approaching 0.5x then conceivably the time has arrived when a doctoral program might be in order at least in certain departments of the engineering college. As the doctoral program increases in scope and size the research budget y will gradually increase and approach the academic budget x. In the great majority of institutions a one to one ratio of y to x will be very desirable.

There will be a limited number of institutions nationally in which the graduate program far out weighs the undergraduate program in number of students, interest of faculty and other specialized reasons. In that case y the research program might exceed x the academic budget. The danger is that y may continue to increase without limit and the institution then gets in an unstable financial position. There are several institutions in the United States today that have reached what amounts to an unstable situation. It is not believed desirable that y ever exceed x by more than a factor of 2 or 3 and then only in exceptional cases. If y should exceed x by a figure larger than that, then the primary function of the educational institution is in danger of being overlooked. Research becomes the controlling factor with the danger that commercialization may endanger the academic pursuits of the institution.

Summary

Summarizing very briefly, then, two general factors have been discussed at this time:

(1) the kind of research which should be done by an engineering college. That can be succinctly stated as a well chosen mixture of basic and applied research with an eye always to the effect of that research on the graduate program.

(2) a well balanced financial ratio between the academic program and the research program. In general where a rather strong doctorate program is in existence the research program dollar wise might approach the value of the ordinary academic budget.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1954 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of Instructional Division Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Sponsored Research in a Large University*

By RICHARD PARMENTER

Coordinator of Research, Cornell University

I have been invited to talk on Sponsored Research in a Large Institution. The institution I know best is, of course, Cornell. I would like to define the dimensions of my subject. Cornell is a University of roughly 9500 students. It is composed physically of eight endowed colleges or schools, and four state-supported ones, at Ithaca; a Medical College and a School of Nursing at New York City; and an Agriculture Experiment Station at Geneva, New York. There is in addition a wholly owned subsidiary—the Cornell Aeronautical Laboratory (C.A.L.) at Buffalo. But this latter is separately incorporated and managed, and will not enter into our discussion today except briefly and then only by specific reference.

The volume of sponsored research at Cornell has risen fantastically since the war. The increase has in fact been 12-fold—from about $790,000 in 1944–45 to $9,451,000 in this last fiscal year.

Of this sum, the State-supported colleges have $5,200,000 or 55%—mostly "budgeted" or "statutory"; the Medical College in New York has $1,500,000 or 16%; the Endowed Colleges at Ithaca, $2,700,000 or 29%.

At C.A.L. there is an *additional* $8,500,000, virtually wholly Government sponsored.

Of the $9,451,000 which will occupy our principal attention, industry supports about 8%, Foundations about 9%, other support 5% and the Federal and State Governments 78%.

Government is thus our largest sponsor. But it must at once be pointed out that ⅔ of Government and State support comes in the form of what I shall term "budgeted" or "statutory" funds. The Hatch Act, Morrill Act, the Bankhead-Jones Act are examples of sources of these research monies which have for many years formed a part of the regular annual budget of the State-supported colleges, leaving to those Colleges a wide latitude in the allocation and disbursement thereof to whatever forms of research seem most appropriate and germane to the interest of the taxpayer.

The remaining ⅓ or about 2½ million dollars comes to the University in the form of Government contract research, and it is this type of support that appears to cause the greatest anxiety amongst educators fearful of Government "domination" of the educational picture. As you can see, it is not excessive at Cornell University, and although this form of support predominates at C.A.L. 150 miles away, its impact is negligible on the campus.

Good and Bad

Such a volume of research has good and bad factors, of course. For one thing, no faculty will stay in an institution which offers no opportunity for research. Research, in balance, makes for better teaching. It affords theses opportunities for graduate students—usually a young man's first emergence into the publication field. And it renders a needed service to the Nation.

Against such obvious advantages are arrayed some equally obvious dangers, to

* An address given before the Graduate Division of ASEE, at the University of Florida, June 24, 1953.

be carefully parried by sound administrative procedures. Otherwise artificial growths in one field, over and above others, may be fostered. There could be a decline in teaching standards. There may arise overdependence upon outside support. Safeguards against these must be set.

Obviously, at Cornell we feel that the blessings of sponsored research outweigh the evils, and the central and all important fact in this conviction stems from our choice of program matter. We have a basic charter which defines the sort of research we are willing to undertake—not just the subjects we are prepared to do research in—but something much more significant—*the definition of acceptability as the faculty sees it.*

These criteria of acceptability are published annually in the report of the Vice President for Research, and while they were embodied originally in an administrative directive of our late President Edmund Ezra Day, they represent actually desiderata formulated and agreed upon by the overwhelming majority of the University faculty. Just as in the case of the University Patent Policy, the Criteria of Acceptability is the result of an operation in Democracy and stems *not* from an administrative fiat from on high, but from the expressed desires of the research workers themselves.

Requirements

The essential requirements of acceptable sponsored research at Cornell are these:

(1) It must be sponsored by—and hence acceptable to—the scientist concerned. *He* initiates the contact with the sponsor, no matter whom.

(2) No faculty member is directed or importuned to undertake any piece of research.

(3) The research must be broad in scope, or broad in method of approach.

(4) The research must be unclassified. There must be free publication not only of the results but of any doctoral theses arising therefrom.

The reasons for these restrictions are obvious; but—it may be argued—this sounds like research conducted in Utopia and not in the United States in the middle of a cold war. How do we get by in our obligations to the Government, for example, if we refuse classified research?

The answer is two-fold. In the first place, we have an equal obligation to the Government to keep our "climate" at its best for adding to the Nation's critically short supply of well taught, well trained, manpower. Classified research in *any* degree, on a University campus, is inimical to the best teaching. Secondly, we *do* assist the Government in its military problems of a classified nature; but we do it at the C.A.L. in Buffalo where 96% of the projects are Government sponsored and most of them are classified. Thirdly, we make our staff available for consultation, when requested, to the absolute maximum of time consonant with adequate fulfillment of their primary obligation as teachers.

Further, we employ a rough and ready rule that no tenure staff member shall spend more than 50% of his time on sponsored research. In this way, pupils who are attracted to the Cornell campus by the prospect of study under a famous teacher will not be disappointed and frustrated by finding on arrival that the great man is immersed in sponsored research, and that his teaching duties have been relegated to less capable hands.

Lastly,—as a further "governor" on the research engine—no one receives additional compensation over and above his academic salary for undertaking sponsored research. The underlying philosophy here is that he has made a free choice and has been under no compulsion to undertake the work, nor has an excessive portion of his time been allocated thereto. It must be obvious that an immense amount of inter-departmental heart-burning and jealousy is avoided by this "no-extra-pay" rule.

Contractual Patterns

The contractual patterns of sponsored research follow roughly these forms.

(1) *The fellowship*—This is a gift to assist a graduate student in the pursuit of studies in a broadly defined field. It is a true gift; and the holder pays no income tax thereon.

(2) *The investigatorship*—Here, the field of research is more or less delimited and a special overseer from the faculty may be designated by the sponsor. Research under this form of agreement often tends toward the applied side. It is a form much used by industry and trade associations, for example.

(3) *The Grant-in-Aid*—This one needs little explanation. It is broad and can cover work in both basic and applied science and carries few restrictions for the worker. Foundations usually allot their funds under such an agreement; but so also do some industries, and certain Government departments, such as the AEC, the NIH, the NSF, etc.

(4) Then there is research done under *contract,* in which the field and subject matter are sharply delimited and some sort of a time schedule—of reporting at least—is set up and adhered to. One cannot speak of contract research without at once thinking of the Armed Services, the NACA, the Rubber Reserve, ONR, etc. Industry more occasionally uses this vehicle of sponsorship.

Impact

Since contract research under Government sponsorship appears to be most closely identified with the fear of an educational system controlled by Government subsidization, I am going to devote a few minutes to consideration of its impact on the Cornell effort.

As I stated earlier, $2,500,000 or 26% of *all* sponsored research at Cornell falls into this category. How and why have we obtained it? How do we man it? How is it paid for?

It is obtained in the same fashion as any other sponsored research—by a direct contact between our scientist and his opposite number in Government. Preliminary discussion may take place at Cornell; at the site of the Government contracting agency; or at a scientific meeting (usually in an air-conditioned bar!). Here, the first ideas are developed and a rudimentary cost estimate is tried on for size. If there is a meeting of the minds, a proposal is formally submitted through the Office of the Coordinator who also signs for the University the resulting contract. *Why* we have obtained any specific contract for research is, of course, implicit in the above. Our man wanted it; the University could house it; and the Government man considered that our people were competent and the price fair.

Once undertaken contractually, the project is staffed by a competent supervisor, aided perhaps by one or two colleagues, and a group of assistants made up largely of graduate students and technicians. The senior men allot a small portion of their research time (never more than a total of 50% to *all* of several projects they may be supervising). The younger men —without University appointments involving tenure—may give part or all of their time to the research. These younger men, of course, are hired on one-year appointments and clearly understand the sources of their employment funds.

The University recovers from the Government the proportionate cost of the manpower involved based on the individual's academic salary, plus an overhead computed on the basis of the "Blue Book." The reimbursement for salaries is used by the institution to supply additional staff to fill any gap caused by diversion of manpower to the project and the overhead is used to cover the indirect costs of the research.

As I have stated earlier, no one gets additional pay for conducting sponsored research. This is a hard and fast rule. Since, however, the faculty of our endowed colleges are on a 9-month year, an agreement with all classes of sponsors

permits a staff member, should he so desire, to be gainfully employed during the summer months on his research project *but not in excess of his normal monthly rate.*

Need Ground Rules

In the good old days, a faculty man did his own negotiating and came up with an agreement that looked good from his own rather narrow point of view. It was a fine system—when the whole operation was small and the cost of living and materials was low—but obviously when a University undertakes research obligations running into millions, you have to use ground rules and some sort of central organization to administer them—as unobtrusively as possible.

At Cornell this organization is headed up by a Vice President for Research and his deputy is the Coordinator. Negotiations for all research in the endowed colleges are finalized in the latter's office and a close liaison is maintained with appropriate offices in the State-supported colleges and in the Medical College.

One fine innovation especially fostered by the Vice President for Research at Cornell, has been the concept of the Research Center—an interdisciplinary gathering-together of talent with common interests across a broad field. Examples are the Housing Research Center, participated in by the departments of Architecture, Engineering, Sociology, Psychology, Economics, Public Health, Home Economics, Labor, City Planning, Public Administration, Law, and Agriculture; the Social Science Research Center is another; the Airphoto Interpretation Center; and the Statistics Center. The presence of such a Center on the campus identifies Cornell with its fields of interest, thus facilitating the raising of research funds. Ideas germinate through active cross fertilization; and last, but not least, of the Center's charms, is the fact that its creation and functioning entails virtually no additional administrative expenses since its housing and staff are already cared for by existing academic budgets. Beyond perhaps an additional secretary or clerk, little increase in personnel is required.

Patent Monies

There is need in a tax-exempt institution for a means to appropriately handle and disburse monies arising in royalties on inventions assigned to the University or on license fees collected under similar agreements. At Cornell this operation is performed by the Cornell Research Foundation, Inc., a wholly owned subsidiary whose Board of Directors is composed of Cornell faculty, administrators, alumni and industrialists. Its two chief officers are the Vice President for Research and the Coordinator. Like the Criteria of Acceptability, the University's Patent Policy represents the considered wishes of the faculty. In general, inventions are assigned to the Research Corporation of New York City for prosecution and exploitation with a small share of the gross going to the inventor and the net profits, if any, being divided equally between the Research Corporation and the Cornell Research Foundation. Each of these latter organizations, by its charter, is obligated to "plow back" these funds into the furtherance of research.

At Cornell University the recipient of patent monies is the Faculty Grants Committee composed of five men from different academic areas, chaired by the Dean of the Graduate School, and with the Coordinator of Research sitting as a member ex-officio. The Faculty Grants Committee we regard as an extremely important body, for the projects which it considers and supports come from areas largely neglected by the sponsors of large, expensive, modern, technological research employing complicated machinery and teams of workers. Here, research is an affair solely of the mind rather than of gadgetry. Supported by these grants—tiny in size perhaps, but rich in cultural implication—we find scholars at their chosen tasks. Here are men serenely working at

research on 16th century polyphonic motets; on a manual of Dragon Flies of North America; on the Life and Works of Daniel DeFoe. This is a pattern of research nostalgic to those of us who are no longer young—the intimate, personal dedicated search for truth—a thing of loving labor and of the spirit, rather than of Univacs and Differential Analyzers. We should indeed be derelict in our primary duty as a University ever to falter in support of this sort of effort.

This then has been the picture of Cornell's answer to the problems of sponsored research. It has been my privilege and pleasure to present it to you. I invite your frankest comments, that in so complex a task we may have the benefit of other experiences and of other points of view.

College Notes

W. R. Turkes, professor and head of the department of industrial engineering at the **University of Pittsburgh**, has been named assistant dean in the Pitt Schools of Engineering and mines.

* * *

A completely new curriculum designed to prepare men for careers in the distribution areas of modern industry will be initiated next fall at **Clarkson College of Technology.** The pioneering curriculum was evolved through cooperative studies by industrialists and educators as broad training for today's needs. By combining the essential elements of the engineering sciences with those of business administration, the new Clarkson Tech curriculum will produce graduates who are uniquely equipped to fill posts of responsibility for which adequate college training has not previously been available. The four-year course will lead to the degree of Bachelor of Science. The major will be in Industrial Distribution.

* * *

A massive windowless laboratory building will go into service soon as new headquarters for **Cornell University's** studies of high-voltage phenomena. The High-Voltage Laboratory, replacing one destroyed in a million-dollar fire in February, 1948, is expected to be in full operation in about a year. Like its predecessor, the structure will be used for teaching, research and testing in the high-voltage field. Incorporating a number of innovations, and designed for easy expansion, the laboratory will rank with the finest facilities of its type.

Research in Small Colleges*

By WARREN E. WILSON *President,* and R. H. COOK *Director of Faculty Research*
South Dakota School of Mines and Technology

I. Introduction

Why haven't we a research program? This is a question that has been, and is being asked by faculty members and administrators of many small colleges. These people see money, apparently poured into the large and great research schools; they see the romance of discovery, the favorable publicity that successful research brings. And these things appear to be good. They question their own failure to participate in today's great research effort. They are told on every hand that national survival, from both the military and economic points of view, demands answers that research alone can give. They have a sincere desire to provide some of these answers. Then too, the same unexplained urge to do research is felt by these men as by any active producer of scientific and technological knowledge.

Any question with as important a basis as that above deserves a carefully developed and honest answer. The purpose of the present paper is to impose suitable auxiliary or "boundary" conditions along with the initial question and then point out some of the most important factors which must be considered in the solution of the problem.

We shall begin by limiting the allusion of the words "research program" in the original question. They shall be considered to imply a program deliberately stimulated and promoted above and beyond that called for in the prosecution of *normal* graduate study. Faculty research which occurs spontaneously under *normal* academic circumstances shall not be considered a result of such a program. It appears reasonable to impose these auxiliary conditions in view of the fact that normal operation should already have received proper consideration and reasonable (if not always adequate) backing and support.

We shall discuss important factors under the broad headings of Research Requirements and Research Effects.

II. Research Requirements

A. Research Minded Staff: Space, time, basic equipment, a good library, and financial support are all essential to a research program. The single most important item, however, is a staff which includes a suitable number of influential, experienced research minded members. The word "suitable" should be applied in one or both of the following ways: (1) Suitable for the entire handling of the research program; (2) suitable as a nucleus to initiate research, inspire the participation of others and provide proper education in research techniques.

Either the small college has such men on its staff or it doesn't have them. In any case they are necessary. This point cannot be emphasized too strongly. The lack of such personnel immediately implies procurement of it. Researchers can be hired on a full time basis. Under the proper conditions they may be secured on a part time basis, or as lecturers, or consultants. Under long range planning, selected staff members may be given leaves

* Presented at the Annual Meeting, ASEE, Graduate Studies Division at the Univ. of Florida, June 24, 1953.

of absence for work in research centers. It may be that a well designed local effort can produce research skill and interest. In any event the method or combination of methods used must produce a research minded staff.

B. Time: Research also requires time. If the present staff is effectively handling a capacity load then that staff must be supplemented whether or not it is research minded. Sufficient additional staff must be obtained to account for the probable load imposed by research, graduate students sometimes are suitable staff supplements, but unless the service they give is greater than the service they require then nothing is gained from the standpoint of time. Usually there is a minimum number of graduate students that can produce a net gain in time. Frequently, in the small college, that number is too large for the equipment and space facilities available. This should illustrate that the problem of time demands careful manipulation. No effort has been made to exhaust the possibilities, in this connection.

C. Library: The small college library is seldom suitable for research. It usually lacks desirable abstracting periodicals, and quite often contains few of the publications in which research papers are printed. A survey of the literature, which may include basic textbooks as well as research papers, is a part of nearly every project. These materials should be easily accessible. Library policy should give the researcher freedom of the stacks, and should permit research periodicals to be checked out for reasonable periods of time. An issue of the *Reader's Digest* can probably be read between four in the afternoon and eight the next morning. An article in the *Physical Review* may take somewhat longer. Services, such as inter-library loans, and micro-film, are great conveniences if not real necessities. The library aspect of research is a basic one. Unless the small college is near an adequate library it will be necessary to provide the proper facilities.

D. Equipment: Equipment is commonly given the lion's share of consideration when research in the small college is discussed. Certainly, equipment is important but not in proportion to the conversation which it inspires. Basic equipment is a must. In any field the laboratory should be equipped to deal with the fundamental quantities, and reactions or processes. A great deal of good research has been done in biology departments which did not maintain a cage of monkeys. Very important results have been achieved in physics departments where not one single atom has ever been deliberately smashed. Much special equipment has to be built by the researcher whether in a large or a small organization. If a worthy project calls for a special, commercially available instrument or device that piece can usually be secured at little or no cost to the institution. We shall have more to say on this point in connection with financial support. Finally, while basic equipment is essential, equipment itself is not a basic issue.

E. Financial Support: Under every previously discussed issue money is implied. Research time means more staff, more staff means more money, and this money must be certain as it cannot be just a speculative possibility. Furthermore, a research staff cannot pull into its shell and stick its head out only for the purpose of announcing results. The researcher should converse with others in his own field, he should visit other groups, he should travel to meetings to present papers and hear other papers. Travel costs money and researchers are almost never overpaid. They will require substantial assistance for this purpose.

Library funds will need to be significantly larger with research than without. The additional expense will involve a periodic component since periodical publications will be purchased. It will involve a steady component to keep up with current books which previously were not deemed necessary. It may be that a rather considerable outlay of cash will be necessary to modify existing facilities and to

purchase micro-film and other new equipment.

Equipment costs can be limited to the purchase of basic instruments and devices which are not already available, and in good condition.

There are other items of expense too, but this paper is far too short to be exhaustive. One expense, which is significant, and which may be overlooked inadvertently is overhead. Heat, electricity, water, gas all cost money and still may almost hide themselves in normal operating expense.

One must remember that these are costs above normal operating expense. As such they represent additional financing problems. What techniques can be brought to bear to carry the added load? There are many; in this discussion only a few can be mentioned.

Many government agencies sponsor projects and give financial support on a project basis. Somewhat typical is the Office of Ordinance Research which will supply funds for worthy projects investigated by competent researchers. These funds can be used for materials, supplies, and expendable equipment (capital equipment too under some conditions). Faculty salaries, during intervals when the college does not pay, graduate student stipends, and wages for assistants can also be included. The OOR will also cover reasonable travel and overhead costs. This agency seems to be primarily interested in basic projects of high quality and of an unclassified nature. This and similar agencies, such as the National Science Foundation, and various branches of the Armed Forces are doing a tremendous job in the stimulation and promotion of research. Policies differ from one agency to another, and government red tape makes the processing of a proposal last from six months to more than a year.

Various privately endowed organizations also provide assistance for worthy research. A very appropriate example is the Research Corporation, which has as an avowed purpose the promotion of research in small colleges. The terms of the Research Corporation are similar to those of the OOR except that faculty remuneration cannot be included. Equipment purchased becomes the property of the institution.

Some of the scientific and engineering societies provide grants. These grants are well worth investigation although they are usually not large.

Endowments by an alumnus or a group of alumni appear to be successful in a number of schools.

Research institutes through which research may be sold as a service have been very successful in some schools and have been flat failures in others.

Again the discussion is not complete, it is meant merely to point the way.

III. Effects of Research

A research program can be good for a college or it can be bad. It can inspire the undergraduate, produce a better atmosphere for the post-graduate, make for a wide-awake faculty, and bring better equipment. Successful research will bring favorable publicity. Through research the small college can increase its service to the nation, the state, and to mankind.

But bad effects are also possible, and sometimes difficult to avoid. The research tail may ultimately wag the undergraduate dog; this has happened far too often. The result, to my knowledge, has never been good. Research can easily become the main criterion for faculty promotion and salary increases. This usually results in a split faculty with the two or more factions actively bucking each other. In this case the quality of teaching goes down, and surprisingly, so does research quality. A research program, once established, will never hesitate to buck the undergraduate program for money, facilities, and privileges, unless it is properly administered.

IV. Summary and Comments

Normal research activity in the small college is not discussed in this paper. By

normal we mean the graduate student research regularly done, and the occasional spontaneous project carried on by a faculty member. It is the writer's opinion, however, that both are desirable and that the latter should be encouraged and given every reasonable aid.

The desirability of the deliberately stimulated and promoted research program for the small college is not easily established. Many factors must be considered. Money is an obvious necessity and great care must be taken that the undergraduate program is not robbed to meet research costs. The very nature of the faculty must usually be modified. This modification unless carried out with wisdom can result in a split faculty and decreased effectiveness of both the normal and research operations.

It is the opinion of the writer that wise administration can effectively eliminate the dangers of a research program to the small college, and that the great good from such a program far outweighs the work and effort required.

College Notes

During the Spring quarter of 1954 (March 24 to June 4) the Institute of Statistics of the **University of North Carolina** will sponsor a special program of course work, lectures and seminars on statistics for research engineers, physicists and chemists. The primary objective of this program is to provide an opportunity for industrial research workers to acquire a working knowledge of modern statistical concepts and techniques. Emphasis will be on the efficient design of experiments and the analysis of data therefrom. Informal seminars on statistical problems submitted by the participating students will be held. Guest lecturers will include Dr. W. J. Youden and Dr. M. G. Kendall. Regular college credit will be granted for course work satisfactorily completed. For further information write to Institute of Statistics, North Carolina State College, Box 5457, Raleigh, N. C.

* * *

The formation of an Engineering Research Institute at **Tulane University**, to serve the needs of the expanding industry of this area, has been announced by Dr. Rufus C. Harris, president of Tulane. Dr. Harris said the institute would contract with industrial firms for specific research projects involving practical problems in numerous fields of engineering science. About 20 faculty members of the school of engineering will take part in the work of the institute, he added, with physicists, chemists and other specialists from various divisions of the university available as consultants on the projects.

*Selected Reports by Institutional Committees on Evaluation of Engineering Education

Foreword

The Committee on Evaluation of Engineering Education, with Dean E. L. Grinter as its chairman, was appointed by President S. C. Hollister in the spring of 1952 to study the impact of expanding scientific developments on engineering education and ways of improving current engineering curricula. It was felt that all engineering educators would take an interest in and could contribute to the discussion. Hence, the Committee discussions were referred to similar Institutional Committees for comment. This "grass-roots" approach led to the development of almost sixty Institutional reports encompassing penetrating analyses of the problem. These reports were of invaluable assistance to the Committee during September, 1953, when the Preliminary Report was drafted. Many suggestions made by the Institutional Committees were incorporated therein. This Preliminary Report, and Summaries of the Institutional Reports representing a perspective of the nation-wide thinking on this subject, were mailed to all engineering colleges on October 14th for further comment and study.

Since no two individuals could brief this wealth of material in the Institutional Reports with identical results it seemed advisable to select several of these for publication in the Journal in abstract form. The seven which follow were chosen because of their unusual analysis and recommendations. This does not imply that the others were not excellent also. Many of them were, but most of these were of such form that they could be summarized as a group. It is regrettable that space does not permit publication of more of these in the Journal. They can, however, be obtained on loan by request.

On behalf of the Committee I wish to take this opportunity of thanking all Institutional Committees and especially those whose reports are published here for their splendid cooperation.

The Committee's task is not yet finished. It is hoped that all engineering educators will have an opportunity of studying the Preliminary Report and Summaries just released, and of discussing their views on this most important subject of Evaluation with their own Institutional Committee before its final report is submitted in early December.

D. H. PLETTA, *Secretary,*
Committee on Evaluation of
Engineering Education

* A summary of the Preliminary Report of the ASEE Committee on Evaluation of Engineering Education was published in the November issue of the JOURNAL OF ENGINEERING EDUCATION.

Abstract Report of the Stanford University Committee on Evaluation of Engineering Education

Being in favor of improvement of engineering education is somewhat like being, with Calvin Coolidge's preacher, against sin. In both cases there is a great temptation to assume that since the agreement is so universal the improvement may be achieved, or the sin eradicated, by showing educators how to teach better or sinners how to avoid sin. This report seeks to avoid this temptation and to search for the basic problems and conflicts which must be identified and solved to effect significant improvement.

1. *Identification of the Engineering Educational Enterprise.* A clear statement of the aims of the engineering education enterprise and some agreement regarding them must precede intelligent discussion of means for improvement. First, it seems wise to attempt to obtain a clear picture of just what it is that engineers do which we wish to educate for.

By and large engineers are paid by society to work on systems dealing with problems whose solutions are of interest to that society. These systems seem to group conveniently into (a) systems for material handling, including transformation of, transfer of, and conservation of raw and processed materials; (b) systems for energy handling, including its transformation, transmission, and control; and (c) systems for data or information handling, involving its collection, transmission, and processing.

In carrying out this work engineers engage in various activities ranging through engineering research, design and development, construction, operation, and management. Within the confines of one or more of these activities the work of an individual engineer is likely to be determined more by the nature of the overall engineering problem with which he is involved than by the particular branch of engineering in which he received his undergraduate training.

The essential unity of engineering endeavor is also emphasized by the extent of the fundamental background required by all engineers in their work. Included in this are knowledge of (a) economic, sociological, physiological, and psychological principles of human behavior; (b) physical principles underlying macroscopic phenomena (consisting of Newton's Laws, the Conservation of Mass, Energy, and Atoms, the State Formulation Principle, the Second Law of Thermodynamics, Maxwell's Electromagnetic Field Equations, the Electric Force-Charge Relation, and the various rate equations); and (c) mathematical logic and the art of engineering design or synthesis.

2. *The Engineer's Place in Society.* If this identification is reasonably accurate, an engineer is a person trained to undertake technical problems of the types listed above. But an engineer, as a professional man in society, is much more than this. The engineering profession is a relatively young segment of our society—as recently as a century ago engineering training was deemed unfit for collegiate instruction. But within the past few decades scientists and engineers have become an extremely influential group in society, wielding a tremendous decision-making power.

In the history of our country there have been many such groups which have exercised powerful control in society. The power of the clergy and of the landed aristocracy has waned; that of the legal and business groups is still felt. In recent years the labor and scientist-engineer groups have been in the ascendancy. With power come important social and moral responsibilities; education for these responsibilities is essential.

The real challenge to the engineering profession today is not in the field of technology. Technologically we have progressed to the point where we may have, if we desire, an impenetrable ring of

radar-fired homing rockets along the Arctic circle, or a six-lane superhighway across the Bering Sea; a guided missile capable of devastating hundreds of square miles, or a food production and distribution system which will insure that no individual anywhere in the world need ever starve to death. The real question is not whether the job can be done—given enough money and people any of these things can be accomplished. The important questions to be answered are of the type, "Given a limited amount of effort and money available, what should be done?"

3. *Education in the Larger Sense.* Those making these decisions involving value judgments must have not only technological understanding, but a broad educational base and maturity. Though these cannot be insured by the fact of four years in college, the college must provide the initial momentum, especially by challenging gifted students to prepare for this future intellectual leadership.

Sir Richard Livingstone speaking at the M.I.T. mid-century convocation in Boston suggested the following formulation of five components of an education: (a) The educated man should have learned to distinguish between searching knowledge of a subject and mere interest in it; thus he has specialized in one area of knowledge for intellectual as well as economic reasons. (b) He should have met man in literature and history and have a sense of the great human values. (c) He should have an awareness of the social and political problems of the day, and of the power and importance of science and technology in modern civilization. (d) He should view his times with historical perspective. (e) He should know the rudiments of the science of good and evil.

It is fairly generally agreed that engineering schools do a reasonably good job of helping their students furnish themselves with the first of these components. With present-day demands on engineers, both for highly specialized knowledge and for broad technical competence in the general techniques of engineering analysis and synthesis, the undergraduate period has become largely pre-professional education. To make the most effective use of this period we must look upon it as merely *the first four years of the education period,* to which will be added the experience of apprenticeship in industry or government and, for an increasingly large proportion, additional formal education.

It is not possible for engineering educators, however, to delegate all responsibility for the accomplishment of the last four of Livingstone's objectives to the church, the home, and the teachers of "humanities" courses and concentrate solely on imparting the first component. Because engineering education is a part of the overall educational enterprise they must assume some responsibility for the success of the overall enterprise, above and beyond the responsibility for the success of their own portion.

4. *The Key Factors.* On the basis of these arguments we may define the proper task of engineering education. Starting from the student with his consuming interest in diesel engines or electronic circuits, it is to carefully lead him to an awareness of his need for, first, a sound theoretical training in basic science, mathematics, and engineering techniques, and second (because this requires more maturity), the development of wisdom through broad experience outside his professional field.

Accomplishment of this task will require good teachers, in quantity. But the more we look into the problem the more one fact seems to stand out clearly—*there are only two important factors in the educational process, the student and the teacher.* The rest—curriculum, administration, structure—are unimportant except as they influence the effectiveness of student or teacher.

The raw material, the student, is to considerable extent out of our control—the second factor is the one we must work with. *We shall have improved education of engineers only when we have more good*

engineering teachers working in an environment in which they can function effectively.

We sometimes forget this important truth in our preoccupation with curriculum and programs. No student was ever taught by a curriculum. Any program is no better than its teacher. On the other hand, a good teacher accomplishes his work within any curricular framework without being unduly hampered.

5. *The Nature of the Problem.* If these arguments are not based upon faulty premises the paramount problem of engineering education (and, of course, of education in general) is twofold. The first part is to educate and induce into the teaching profession a sufficient number of that kind of teacher whose individual impact on the student can accomplish what no curriculum in itself can do. Secondly, these teachers must be provided with an environment in which they can function with maximum effectiveness.

A great deal can be accomplished toward these ends by engineering teachers and administrators. On the other hand, the historical record indicates that really profound changes will depend upon factors outside the university. For, in the final analysis, the trend of engineering education is strongly influenced by long-range social forces. The attitude of society determined to a large extent whether any activity will flourish or decline.

Research is a case in point. In Germany during the first half of the last century research flourished because its future importance had been sensed by the people and leaders of that country. In this country and Great Britain there was no such support, and research activity languished. Later, when it was apparent that leadership in research was an important source of German power, the attitude of society shifted. Philanthropists endowed great research projects, government and industry began to build up research organizations. In the space of a generation empirical research leapt from the position of seeking support to that of the most highly-honored activity in the university.

Thus if education in the larger sense, as defined earlier, is to flourish, this must come about because society has come to hold that education in esteem and to actively support it. Financial support, while important, is simply a tangible indication of moral support. If it should become apparent that industry, government, and society in general value the wisdom and perspective of the broadly educated man above vocational or professional training (as society in this country once did) then we would find our engineering students and professors integrating their technical knowledge with studies of history, philosophy, and literature. So long as the scale of values remains with specialized professional training ranking near the top, there are imposed rather rigid restrictions as to what changes can be made within the universities.

Our view of the problem of engineering education effectiveness must be, like the education we wish to produce, broad and searching. By examining the position of the engineer in society and the tools he needs to fulfill this position successfully we can come to some conclusions as to what our aims should be. To see whether these aims are likely to be accomplished it is important to note whether they conflict with the attitudes of society. In this way we can concentrate on the aims which can be realized by efforts within the university or, if we choose to pursue programs whose success would require a shift in the attitude of society we can at least recognize the magnitude of the undertaking.

J. B. Franzini
W. G. Ireson
S. J. Kline
W. W. Harmon, *Chairman*

University of California, Los Angeles Committee Report on Evaluation of Engineering Education

Introduction

"Probably the most significant single characteristic of the engineering educational field is that it has no generally accepted professional objective as a goal for the educational program."

The two main long range goals of this study are: (a) to provide a basis for the coherent development of engineering education in the United States and Canada adequate to serve the needs of the ever-present future, and (b) to develop a measure of the existence and adequacy of such engineering education. To achieve these long range goals, the problem of engineering education must be examined in its broadest social and professional setting unrestricted to the college program per se. Consideration of such setting leads the committee to propose that the differentiating characteristic of engineering education lies in its motivation and methodology. This the committee amplifies via the following terse statements.

Nature of Engineering

The subject matter of Engineering has at all times been fundamentally rooted in the physical sciences with a varying and generally increasing emphasis upon the biological sciences. The ever-receding boundaries of the engineering system make difficult the characterization of engineering purely on the basis of subject matter.

In the recent past concerted efforts have been made to evolve the distinguishing characteristic of engineering. Receiving the most attention has been the term "design." Some persons imply that design includes the functions of explanation, prediction, and evaluation. Design also carries with it the implied query "of what?", and the answer generally has been "engineering works." These include structures, circuits, machines and processes of scope sufficient to meet the demands of mass production. The profession, in focusing on "ability to design" engineering works, has clarified a distinguishing characteristic of engineering.

Interrogation of nature must be unceasing and engineering action cannot await a complete reply. A full reply constitutes formulated knowledge or science, and this often comes via unformulated knowledge or empiricism. Engineering deals wholly neither with formulated nor unformulated knowledge, and the unformulated portion must be in transition toward formulation. Pure science and expert craftmanship are thus at the boundaries of engineering.

Historically, the outcomes of engineering activity have been rather immediate combinations of readily available materials and obvious forces of nature—and these have resulted largely from strict ingenuity and experience. The "putting-together" of today and tomorrow—a synthesis—involves a measure of abstraction not heretofore present. But in functioning in the design role illuminated above, the engineer, no matter how abstract the problem, employs a definite putting-together methodology. Thus, the essence of engineering is and will be the methodology of design.

Definition of Engineering

"Engineering consists of creative, comprehensive thought and resourceful, effective action directed—through the methodology of design—toward the evolution, evaluation and accomplishment of socio-technological objectives, and means thereto within a physical environment."

This clearly identifies engineering as the agent and advocate of society with physical nature, and also makes clear an essential essence in the execution of the tasks, i.e. through design. Methodology of Design consists of:

(a) the exercise of tolerance, rational method and the discriminatory use of both science and empiricism pertaining to the whole problem;
(b) the understanding of significant properties and behaviors of several physical environments;
(c) the functions of explanation, prediction and synthesis relative to production, distribution, control and utilization of the energy, material and information of nature as supplemented by the resources of men, and
(d) formulation and use of technical, economic and social criteria for effecting decisions leading to optimum outcomes in a framework of constraints.

Nature of Engineering Education

"Education is the process by which man evolves. It includes all experience, all learning, all growth, all development. In itself it is neither good nor bad. . . ." Engineering Education refers to the process by which the Engineering Aspirant becomes a Professional Engineer.

The term "Engineering Education" will, for the sake of ease of reference refer primarily to the college program. However, its function and nature must be definitely determined by the subsequent industrial training.

Engineering Educational Program

An engineering program becomes optimum preparation for industrial training when (in part) it provides a realistic proportion of the basic constituents of design: science, language (including mathematics), experimentation and application, and methodology (including philosophy, problem solving and integration of knowledge). Such is certainly not true of usual programs in college science, mathematics, or applied (industrial) arts departments. "Applied" physics and "applied" mathematics are potentially confusible with "engineering" physics and "engineering" mathematics. Similarities and/or differences may be traceable only to the motivation and examples of both students and staff. In a very real sense, it appears that the (pure) science or mathematics content of an engineering program has an upper bound rooted in basic motivation! This helps undergird the proposition that the engineering program is distinguishable by its mixture and approach.

Professional society gatherings, field trips, cooperative work-study programs and campus cultural activities engender professional attitude and enrichment of personal experiences. Such cocurricular activity is a recognized part of an engineering college program although it requires much exploitation to better meet the demands of the future.

One basic attitude of particular significance to engineering is non-authoritarianism. The product of teaching so directed is a thinking, creative student who so appreciates where knowledge comes from that he knows how to go about knowing new things. Education provides frames of reference which gives meaning to experience.

Core Disciplines for Optimizing Preparation

"The purpose of the four years spent in college is not to teach students what to think, but how to think and how to learn from experience. . . . (Furthermore) industry looks for men who have the ability to get things done."

A significant function of Engineering Education is selection of those qualified on the basis of personal as well as mental traits, and their motivation to become engineers. The caption of "Core Disciplines" perhaps implies a certain level of rigor which, of itself, will fulfill a selection function. In the overall engineering college program, consideration should be given to opportunity for relaxation and contemplation, cooperative work-study experiences and co-curricular activities.

Conclusion

Accreditation is concerned with "approval" of certain educational programs meeting certain minimum requirements.

Such approval has been accepted by society, as a whole, as an indication of minimum standards of performance or competencies relative to the practice of engineering. It serves as a partial basis for legal and professional recognition of engineers and at the same time helps safeguard the safety and "welfare" of the public; the latter is undoubtedly a necessary function to be performed in our society.

An attitude of intelligent daring and experimentation—rather than conformity—is both the safeguard of and the springboard into the future. The colleges and industry should help the ECPD formulate "the minimum" and together they must go "the second mile." Moreover, this cooperative self-evaluation must never cease, and, to this end, the philosophy of the whole accreditation program should include the concept of continual review.

J. C. HARPER
J. W. MCCUTCHAN
C. L. SONNENSCHEIN
D. L. TRAUTMAN
L. L. GRANDI, *Chairman*

Evaluation of Engineering Education Reported by The Institutional Committee at Cornell University

The committee's approach to this study has been through critical consideration of the kinds of work our engineering graduates will be doing in the years to come and the problems and responsibilities they must meet. It was agreed that engineering students must be trained to do competent professional work in their first positions for without such preparation they may not have opportunity for promotion to greater responsibilities. However, mere preparation for the first job is not enough. Our training must also provide the basis for advancement. The better the young engineer's future duties and responsibilities can be anticipated, the more clearly can our training objectives be defined. This, in turn, should be the basis for modification and improvement of curricula.

It was recognized that training in specific fields of engineering will lead to differences in the kinds of work and responsibilities for our engineers. These differences must be considered in assessing the adequacy of curricula. There is, of course, some preparation basic and common to all curricula in engineering. Every engineer should have adequate preparation in mathematics and in physics and chemistry and the other sciences on which his technical work is based and in mechanics, thermodynamics, materials of construction and the other commonly fundamental applied sciences. Every engineer should be able to write and speak correct and effective English; he should have some knowledge of the history of the civilization in which he lives and of the impact of his professional work on that civilization. He should be prepared to deal effectively with the economic and social problems that arise in connection with his professional work. Beyond this common basis, the curriculum in each specific field of engineering should be formulated to prepare the graduates for effective professional work, and with regard to probable ultimate as well as immediate nature of that work.

Engineering Trends

To an increasing extent research and development divisions in industry are being filled with men with engineering training. This trend is due in part to the recognition that a man with engineering background is well qualified to do research, and in part to the use of the development division as a training school from which men may be drawn to fill

positions in supervision and management.

Within the past few years, engineers have been employed in increasing numbers in other than strictly technical capacities and have advanced more and more frequently to the top positions in management. It is reasonable to assume that this trend toward the use of men with engineering training for work that is not purely technical will continue and increase.

In the future, it is expected that industry will place greater emphasis on the research and development effort. It seems likely that industry's concept of research and development will broaden so that it guides and stimulates all phases of company operations including sales, distribution, product quality and raw materials as well as manufacturing. The role of the engineer includes participation in research and development in some cases, but also covers the guidance of research programs and policies and the utilization of research results. Whether the young engineer's assignments are in research and development, engineering, plant operations, purchasing, sales or any other division, his problems are technical. The effective solution of these problems requires the use of technology intimately mixed with economics and human relations. Professional advancement to supervisory, administrative and management positions comes after he has performed well in technical jobs. It is believed that research and development will be a major stepping-stone from which future engineers will proceed to more responsible and diverse situations. This trend appears to be less significant in civil engineering. In all fields, it is believed that the trends toward greater diversity in the kinds of work and more rapid advancement to managerial and supervisory positions will continue and become more pronounced.

Another trend which will have an important effect upon engineering education is the technical institute movement. In the last ten years, many such institutes have been started throughout the United States and are proving that they can train adequately for many of the minor jobs which previously had been filled with engineering graduates. This movement will tend to confine the outlet for engineering graduates to the professional phases of engineering which in turn means that engineering colleges will have to provide the broad and deep training necessary for professional leadership.

Training Requirements

With the rapidly increasing extent of our knowledge of science and engineering and the increasing breadth of training required for effective professional work in engineering, the graduating engineer must know about more kinds of things than was required or even possible a few years ago. We cannot expect to crowd all of this necessary training into the already full curricula unless we make room for it by increasing the effectiveness of instruction in the existing courses.

This does not mean that the training in the present basic and essential subject should be made more superficial; it does mean that our existing courses should be re-examined critically to eliminate non-essentials and to be sure that important topics are covered clearly. We should review our teaching methods to insure that the time spent in the classroom and the laboratory is used as efficiently as possible, and to eliminate needless duplication and unproductive effort on the part of both the staff of instruction and the student body. Many of the courses in our universities are taught in about the same manner today as they were taught thirty years ago. Perhaps this is the best way, but we should not assume that no improvement in the course content or the method of instruction is possible until we have made a critical study of both scope and method.

It is possible that we take too seriously the mere mechanics of curriculum carpentering and that if we concentrated more on the broad nature of the training and less on the titles and credit hours of

the several courses, we could provide better preparation with less unproductive effort on the part of the student. We should expect that any capable man will continue to intensify and broaden his education after he leaves the university; we should realize that all that the university can do is to provide the foundation for the real education that should continue throughout his later professional life.

In general, then, those of us who are charged with the responsibility of training engineers for successful professional work in the years to come should ask ourselves:

1. Do our present training programs give adequate training to enable the graduate to do satisfactory work in his chosen profession?

2. Do the present curricula include work not of sufficient value to justify their retention?

3. Do they provide him with a foundation on which to build his later training by experience and study for positions of higher responsibility?

4. Can we, by critical study of course content or methods of instruction, improve the effectiveness of our teaching, even if such improvements require complete revamping of our present courses?

To accomplish our aims students need more practice not only in solving problems, but in formulating them. They must learn in school how to apply what they know to new situations and they must be encouraged to follow advances in technology and to make these new developments part of their working knowledge. As teachers we must assume responsibility for personal and professional development in addition to the training we give in the fundamentals. All this suggests some changes in curricula, but it does not necessarily mean crowding in more courses. Much additional learning can be introduced through the courses we already have. What we do need is more effective teaching.

Objectives of Different Curricula

Engineering education cannot, however, be confined to the study of basic principles. The ways in which engineers use fundamentals in their profession vary so greatly between the different branches that some emphasis and training must be directed toward specific applications in each field. Facility in applying fundamentals requires practice and experience in their use. In each branch there are unit operations and processes, techniques and types of equipment common to whole groups of industries which may serve to illustrate application of principles. Differences in type of employment, field of activity, and kind of work lead to different training objectives and different curricula in the several divisions of engineering.

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N. H. Bryant
N. A. Christensen
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Abstract Report of the Johns Hopkins University Institutional Committee on Evaluation of Engineering Education

The problems currently facing the field of engineering education are the result of our present attempts to teach the bases and facts of an enormously expanded science and technology in the same number of school years considered to be adequate half a century ago. There is more for today's engineering students to learn than there was years ago. The universities and colleges are being pushed from another

side as well. Today for example it is uncommon for the college freshman to meet the calculus. Courses in algebra and trigonometry are common in this first year, with the result that those courses requiring a knowledge of the calculus as prerequisite must, in most cases, wait until the third year. Furthermore, in the vast majority of cases the colleges are forced to take the major role in developing a command of the English language and a modicum of self expression in the student.

This is the problem: An expanding science and technology to be crammed into a period of time which must be limited by the economic and social pressures on any student; a need for increased attention to the formative freshman and sophomore years; and, with all this, a need for a recognition of the necessity of the various social and sociological phases of university education and their importance to the individual and his place in our society.

One solution to this problem becomes apparent after close scrutiny of the demands and hiring techniques of industry. Industry needs and hires men for two distinctly different levels of engineering work. The first level is a purely operative level, the second, or "scientific" level, is a level at which the research, planning, and decision making is carried out. With the increasing complexity of modern industrial operations, the degree of educational background required for this second level of activity is increasing yearly, whereas the requirements for the former have remained almost static.

Split Curriculum

It seems to the members of the Hopkins Institutional Committee, therefore, that engineering education might best proceed toward the development of a split curriculum. As an example of the manner in which this type of curriculum might function, the following is proposed.

The first two years of engineering education might well be the same for both curricula. The "scientific" curriculum would then offer courses of a very fundamental nature and of a type emphasizing the interrelationships between the fundamental theorems of basic science and applied engineering. It is felt that this course could not be completed in the normal four years of undergraduate training but must, necessarily, extend into those portions of the present curricula now normally reserved for graduate studies.

Those persons judged best suited for the operational level would initiate (following the two years of basic liberal arts and science training) two additional years of training leading to the baccalaureate degree, to be considered, for them, to be terminal. These two additional years would emphasize the practical or applied phases and would pass lightly over the theoretical.

The committee faces the fact that this plan presents certain problems. These might be divided into two categories, namely problems of a psychological nature and problems of a purely administrative type. Considering the first of these, it must be obvious to all that there is no stigma attached to either of the proposed curricula. Provision must be made for reevaluation of a person's interests and abilities such that it is possible to change from one program to the other. Administrative problems would be those revolving around such questions as: (1) What should be the subject matter and subject emphasis for each type of curriculum? (2) Should there be separate institutions specializing in each type, or should each institution attempt to do both jobs?

Subjects for Discussion

The following subjects are proposed for future discussion of this committee. It is felt that the crystallization of ideas on each of these topics will materially benefit this evaluation program.

(1) To what extent should engineering education broaden its attention to the field of "Expanding Fundamental Sciences"? Should more introductory-type courses in diverse new fields be introduced or should

more searching and minute attention be directed toward developments in a special field?

(2) What is the nature of the job the colleges and universities are *supposed* to do in preparing and training engineers for industrial positions, this from the point of view of the industries doing the hiring?

(3) What is the most advantageous distribution of humanities-type courses in both curricula? Parallel to this is the problem of the distribution of the basic sciences.

(4) Some attention must be directed at the problems involved in teaching mathematics to engineering students in both portions of this split curriculum. In particular the merit of the "pure" approach vs. the "applied" approach must be examined.

The Hopkins Institutional Committee has thus far devoted a major portion of its discussion to the desirability of and the problems involved in the idea of the split curriculum. The members of this committee are not unanimous in their thinking on all phases of this idea. It seems, however, to be the consensus that it is basically a good idea but one to which much further thought must be devoted.

W. C. Boyer
D. H. Fax
T. Larsen
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H. E. Hoelscher, *Chairman*

Abstract Report of the McGill University Committee on Evaluation of Engineering Education

A gradual change in engineering education during the next quarter-century can be anticipated, chiefly on account of advances in technology and wider diversity of applications of science. The widening field will compel a more fundamental and a more generalized treatment of subject matter, because individual treatment will no longer be practicable in the usual span of the course. Adequate coverage will be possible only by permitting a greater degree of penetration of fundamental physics, chemistry, thermodynamics and geology, into the courses, and by unification of courses and fragments of courses, together with emphasis on those things which are least likely to change. The content of existing courses will undergo changes parallel with the evolution of practices. Engineering teaching will become less specialized but without dropping any of the present main divisions. Lectures will have to deal with less practical aspects and more with basic principles. The demands of time will force a more extensive use of demonstrations and visual aids wherever possible in place of laborious testing experiments.

The training of engineers will have to take increasing notice of their position and influence in society and their recognized adaptability for administrative and managerial positions. A greater content of the life subjects, including psychology, will be desirable in engineering courses. This trend will necessitate a broadening of curriculum along non-technical lines, with lessened emphasis on purely technical aspects. A searching examination will have to be made of all courses to find the time in which to offer these subjects, if the length of the course is not to be extended. The desirability of broadening the curriculum along these lines seems to be favored by most engineers. A wider selection of options may be the answer in some cases, but a too-wide scale of options in the undergraduate years leads to undesirable specialization. In the undergraduate years, the probable trend will be towards strengthening the basic engineering training. Some specialization will re-

main but will enter at a later stage than is the case at present.

Collaboration with Industry

There will be an increasing trend in industries to train graduates in their particular technology and specialized professional work, and this will enable more general and more thorough treatment of basic subject matter at the university. It is probable that collaboration with industry will be greatly increased, and this may lead to an extension of the practice school and cooperative course ideas. Teachers will find need for wider industrial experience to keep up with changes in technology.

The development of the engineer capable of understanding all aspects of a whole project, and its direction, will be a major problem in engineering education in the coming years. In the planning of curricula, authorities must never lose sight of the degree of maturity, mental outlook, and personality, of the young engineering student.

J. B. PHILLIPS, *Chairman*

Abstract Report of the Oregon State College Institutional Committee on Evaluation of Engineering Education

Answers to questions prepared by ad hoc sub committee

1) *What trends in development and/or exhaustion of our natural resources appear likely to affect engineering practices in the next 25 years?*

The rise of nationalistic feelings and industrial development in heretofore undeveloped foreign nations will tend to make us more dependent upon our own reduced resources. Population pressure and maintenance of the living standard will demand the conservation and efficient utilization of all our natural resources. Increased production costs and depletion of high grade reserves of many of our resources will make necessary the economic development of low grade reserves and in some cases the substitution of materials. Some of these possibilities are outlined below:

a) *Petroleum.* Our national petroleum reserves in the continental limit of the United States are becoming smaller in time of years supply available to satisfy our needs. Higher labor costs and deeper wells are making petroleum products more expensive. The continuation of this trend will restrict the use of petroleum products as fuel since they will be needed in the manufacture of more expensive and valuable chemicals.

b) *Metals.* The end of high grade iron ore deposits in this country and the resultant increase in the cost of producing steel will result in the wider use of aluminum and magnesium as structural materials in all fields of engineering. Copper and lead will also have to be replaced in many of their present applications.

c) *Water.* Continued growth of population and depletion of the ground water reserve will force intelligent planning on a regional or national level for the efficient use of our water resources. The increased cost of domestic water because of longer conduits or more expensive treatment may make the purification of sea water feasible. The mineral content of sea water may be a valuable by-product.

2) *What recent developments of familiar materials and introduction of new materials appear likely to modify engineering science and practice in the next 25 years?*

The use of light weight aggregates and prestressed steel for structural concrete

and the substitution of other materials for steel will force revision of building codes and shop practices with more emphasis on engineering the individual project. Recent development in new alloys for magnetic materials and research in the field of dielectrics will change the design and production of electrical equipment.

Materials which can withstand high temperatures and also have high strength are needed in many fields. Because of their resistance to high temperature ceramics may offer possibilities.

3) *What seems likely in the development of power sources in the next 25 years?*

4) *What developments in fuels (for example, the metals) are likely to modify power production in the next 25 years?*

The current trend of more horsepower per person will be accelerated by the depletion of our natural resources quoted above. This will necessitate the ultimate and efficient development of hydro-electric sites in all parts of the country. A nationwide pooling of all generating facilities would contribute to the overall efficiency.

Atomic energy is in the process of development for both stationary and mobile units. Successful development of this source will depend upon an adequate supply of raw materials, economical methods of preparation and protection of personnel against radioactivity in large and small units.

The relatively large reserves of coal and shale oil may be used in gas turbines or jet engines to replace petroleum products as a fuel for prime movers. Gasification of coal in place with power development at the mine is a possibility.

Other possibilities in power development are (1) solar energy, (2) power from the wind, (3) direct conversion from fuel to electricity.

5) *What developments in the art and science of automatic control will be significant in the next 25 years?*

In order to get a more uniform product and reduce human effort, automatic control will continue to spread through industry. The flexibility of control equipment will be increased with the introduction of electronic computers which may dictate changes in control with changes in conditions. The use of automatic control (with computers) to operate power system or the traffic control system for a city are illustrations of the possiblities.

6) *What in the life sciences (including psychology) are likely to be important in engineering in the next 25 years?*

Continued research in the life sciences may permit development of a quantitative treatment of these sciences through some branch of mathematics, and thus give information to the engineer in usable form. In other words, quantitative treatment may give the engineer sufficient tools to evaluate the effect of his works upon society. Problems which will face the life scientist and have significance for the engineer are: (1) the effect of automation if carried to the extent possible; (2) recognition of unnecessary and avoidable hazards in current living and demands for minimizing these hazards; (3) dispersion of the population; (4) higher average age of the population; (5) necessity for planning resource development on a national level.

7) *What changes will occur in engineering practice during the next 25 years?*

The increased cost of labor and materials will make careful engineering design economically feasible and will encourage research and development. On the other hand, the use of electronic computers even in small engineering offices should reduce the time required for routine computations. Simplified drafting practices may further reduce the engineering time spent in a routine manner.

With reduced time spent on routine and the means at hand to solve complex problems economically more engineering time will be spent in the collection and analysis of data for the individual design. The practicing engineer will have to be more familiar with mathematical analysis and

will need a more complete understanding of economic and social trends than he now has.

8) *In your opinion how will engineering education 25 years from now contrast with present engineering education?*

The growth of Big Industry in the last half century suggests that it will in the future wish to train the young engineer in a specialty; and since more graduates will find employment in such situations rather than in small businesses, the bulk of the demand will be for men with a general, rather than specialized, training. This would indicate a shift in engineering education toward the unification of the individual curriculums such as Civil, Electrical, Mechanical, and Chemical Engineering into a unified course which might be called "Engineering." Further development along these lines may lead to unification of Chemistry, Physics, Mathematics, and Engineering into a course called "Science."

The general training which the engineering graduate will receive will be on a higher scientific level with a much greater emphasis on mathematics, physics, and the applications of physics which cut across all the present branches of engineering. Design procedures and industrial "know-how" will be de-emphasized.

The continuation of the current trend will concentrate the bulk of research and development of basic and applied science with industry rather than the colleges and universities. The graduate work in engineering will be concerned with a "professional" curriculum of perhaps two or three years to offer specialization to those men who wish to go into consulting work or engineering teaching.

Engineering faculties of the future will be expected to teach at a higher scientific level with more emphasis on theory and less emphasis on practice.

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L. A. CLAYTON, *Chairman*

Abstract Report of the Illinois Institute of Technology Committee on Evaluation of Engineering Education

Introduction

Studies of the Illinois Institute of Technology Committee were limited to: a) basic principles, b) creative thinking, c) research, and d) professional development. Before discussing these items some problems peculiar to engineering education are outlined briefly. The subjects listed then are presented in the order named.

Problems

The four principle phases of a well-rounded engineering education involve training in: a) communication skills, b) science, c) planning and design, and d) professional or social development. Communication skills include English, mathematics, drawing, surveying-mapping, and other related subjects. Proficiency in these areas makes possible most effective use of knowledge acquired in other phases of engineering education. Although technology in the past often preceded science, full development of any modern engineering undertaken can be realized only by the application of scientific principles. Whereas the scientist is interested in determining what will happen if certain elements are combined, the engineer is interested in determining what elements must be combined to perform a specific function satisfactorily. Planning and design are the syntheses of facts and desires,

often conflicting, through the application of scientific methods. The modern engineer plans, designs, builds and maintains projects and services which affect the lives of everyone. To be of maximum value to society, he must have an understanding of his duties, his opportunities and his moral and spiritual obligations to that society. The foundations for such understanding, of course, are established long before the engineering student reaches college, but these teachings must be augmented through his formal education.

It is not difficult to establish goals. The real problems arise in connection with: a) obtaining the personnel qualified to teach adequately the subjects and overall philosophy of the profession, b) determining the proper combination of subjects to teach, c) integrating each curriculum so that each part supplements the other parts, d) developing the confidence and enthusiasm of students to progress beyond minimum requirements, and e) selecting and using methods of measuring competence. Also there are the problems of minimizing such factors as a) inadequate physical facilities, and b) interference with the educational program caused by requirements of military services and other activities. These items of course do not exhaust the list of problems faced by engineering education but they highlight some of the important ones.

Basic Principles

What principles of what subjects should be included in the undergraduate curriculum of an engineering college? A thoroughly integrated program would limit the number of principles taught to those which would be used in later courses. Actually these probably would be the only ones retained by the student anyway. Mastery of a limited number of essential laws would be far better than a superficial knowledge of expanded subject matter. Creative thinking, so essential in professional work can result only after basic laws are mastered.

Creative Thinking

Creative thinking is a characteristic of professional engineering. First, however, students who have the requisite aptitude must be selected. Special abilities are necessary for mastery of tool subjects, e.g., mathematics and physical sciences. High general intelligence is required to utilize acquired information in practical situations. College entrance tests are reasonably good tools for selecting the student whose general ability is equal to college work. One direct way for engineering schools to improve quality of graduates is to devise tests which specifically evaluate aptitude for engineering. A program of this kind could be undertaken at once with data already accumulated.

The first step in creative thinking is the definition of the problem. The student can be helped to learn to think creatively if the importance of defining his problem clearly is emphasized. The next step is examination of available information which can be utilized. The final step is organization of information in a way to effect a solution or to define the area in which additional information is necessary. This is the process by which advances are made in all fields of science, pure and applied. The engineering student should be taught this process and should be given extensive practice in applications to real and hypothetical problems. After two years about 25 per cent of factual material is retained, but the method of attacking a problem and the technique of transferring pertinent information persist once they are acquired. Research is one activity which helps to develop creative thinking.

Research

The philosophy of expanding science is considered to mean the principle of complete freedom to follow interesting paths of investigation wherever they may lead. The application of this philosophy yields fundamental research and is therefore the essence of advances in basic science. The engineering student should be made to

realize that the continued application of this philosophy is imperative because results from fundamental research today are the foundations for practical developments tomorrow. Thus the future of the engineering profession is closely related to discoveries made first as a result of fundamental research in pure science. Many large corporations are keenly aware of the importance of fundamental research and dedicate a significant percentage of their research budgets to such activities. Young engineers should be made aware of such programs and of the importance of expanding them. Consideration should be given to including in the first year a course or series of lectures to introduce the students to this relationship between fundamental research and engineering, as well as to introduce many other factors affecting professional and social development.

Professional and Social Development

It is practically impossible under the present system to give in four years a general education and a professional education. Engineering might have to adopt the practice of medicine or law in order to attain the same professional status. Beneficial effects accrue from extra-curricular activities of various kinds. Professional attitudes and ethics might be inculcated as much by example in the daily classroom as by the prepared lecture. Teachers themselves who believe and practice professional standards, attitudes, and ethics teach indirectly through example.

Recommendations

The only recommendations which the committee cares to make in this first report are concerned with creative thinking. These are:

a) More effective use should be made of existing selective tests.
b) Engineering faculties should cooperate with psychologists in developing tests designed to measure abilities required in specific engineering fields.
c) Engineering courses which emphasize transfer of material from the theoretical to the applied should be developed.

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H. P. VINCENT
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Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.

American Society for Engineering Education Committee on Atomic Energy Education

Future Activities of the Committee

A Report to the General Council of the Society, June 26, 1953

In the three years during which the ASEE Committee on Atomic Energy Education has been in existence a reasonably definite pattern has emerged which indicates its general fields of activity in the future.

The first important responsibility of this committee is to act as a liaison group between the ASEE and the AEC. Such matters as declassification by AEC of nuclear engineering information, and AEC policies with respect to support of engineering education by such means as engineering fellowships, nuclear engineering facilities at engineering colleges, and development by AEC of teaching aids, are topics for discussion by the committee. The committee is in a position to give the AEC advice as to what policies might be desirably adopted in this field, and to obtain information for the colleges from the AEC as to what is feasible from the standpoint of budget, facilities, etc. Accordingly, it may be assumed that the committee will serve an important role in the future to transmit information back and forth between engineering educators and the AEC.

The committee has at present two active sub-committees. The first of these has been appointed to follow the progress of the "Sourcebook on Nuclear Engineering" and give advice to the authors as to the treatment of the subject matter in this book. The necessity for a "Sourcebook on Nuclear Engineering" was discussed by the committee at its meeting in 1951 and the committee requested the Atomic Energy Commission to prepare such a book. The Commission agreed to do so and enlisted the services of Dr. Samuel Glasstone to undertake the writing, with engineering advice to be obtained from the staff of the Oak Ridge School of Reactor Technology. The Oak Ridge National Laboratory has designated Mr. Neal Lansing to represent ORNL in this activity. A classified text is well under way, and the committee has been called upon in the past to furnish advice as to the level to which the material should be written and the subject matter to be included. The sub-committee will continue to work with the authors in developing an effective classified text for use by AEC installations and later in adapting this text to produce the best possible book based on declassifiable information. It is expected that the work of preparing the declassified text will be completed by the late spring of 1954, and it is hoped that the book will be available for classroom use during the academic year 1954–1955.

Facilities Expensive

The second sub-committee is directing its attention to the problem of facilities for studying nuclear reactors in engineering schools. The expense of such facilities has been a deterrent to their use, and there is some question whether many engineering schools are in a position to afford the outlay for even the smallest nuclear reactor. Accordingly, the sub-committee

will include in its program a study of reactor stimulators and other electronic devices which may be used for study of the behavior of nuclear chain reacting systems. It is expected that the task of this sub-committee will be a continuing one for some years, inasmuch as the field is constantly changing. Interest in nuclear reactors on the part of engineering institutions may be expected to increase markedly as industry is brought into the nuclear energy field and makes demands upon the engineering educators for engineers prepared to work in the field.

The committee feels that much more work needs to be done to bring to engineering educators the significance of the U. S. atomic energy program. A number of regional conferences of the ASEE have been devoted to this problem. Most of these have been on an elementary level, designed to present the basic nuclear energy phenomena to engineering staffs. More of these are needed. For example, there has not yet been a conference of this type in the Midwestern region, but one is being planned for this fall. Educational conferences on a higher level are also necessary since there is, as yet, no real agreement among engineering educators as to how nuclear energy should be adapted to the engineering curriculum, and how much of it should be taught in the graduate and undergraduate engineering courses.

New Trends

Finally, new trends will inevitably develop in the U. S. atomic energy program as a result of the operation of two forces. First, the efforts to reduce the U. S. Government budget will undoubtedly have an impact on the atomic energy program, and may have an adverse effect on the funds which the AEC will have available for education and training. The second factor is that the need for education and training will become increasingly acute as the pressure develops to bring American industry fully into the nuclear energy program. It seems apparent that the Committee on Atomic Energy Education will find itself faced with, as yet, unforeseen problems as a result of these tendencies.

Respectifully submitted,
HENRY H. ARMSBY, *Chairman*

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Forecasting Academic Achievement in the College of Engineering

By L. E. DRAKE, *Associate Professor of Engineering*

and

W. F. THOMAS, *Assistant Director of Student Counseling*

University of Wisconsin

In counseling students enrolled in the engineering curriculum it is helpful to identify those students who are likely to have academic difficulty as well as those who should achieve highly. For purposes of such identification the Pre-Engineering Ability Test,* Form ZPA, was administered to the entering freshmen in September 1951 and September 1952. By agreement with Dean M. O. Withey, in order to insure that course grades would be entirely independent of the test scores, the scores were not reported to the College of Engineering until the first semester course grades had been recorded.

Centiles, based upon University of Wisconsin norms, for the 1948 Edition of the American Council on Education Psychological Examination were available for most of the students and the rank in the high school graduating class converted to centiles were available for many of the 1952 group. Only those students who carried 12 credits or more the first semester were included. The index of scholarship was computed by assigning 3 points for each credit of A, 2 points for each credit of B, 1 point for each credit of C, 0 points for each credit of D, and by substracting 1 point for each credit of F. Thus grade point averages could range from 3.0 to -1.0.

Table I shows the grade point averages of the Engineering Students for the first semester as classified into various quarters on the basis of the Pre-Engineering Ability Test and the American Council Psychological Examination.

First quarter refers to the upper 25% based on local norms for the American Council Psychological Examination. Raw scores were used for the Pre-Engineering Ability Test grouped as follows: 1st quartile $52 \rightarrow$; 2nd quartile $43 \rightarrow 51$; 3rd quartile $36 \rightarrow 42$; and 4th quartile $0 \rightarrow 35$. As indicated in Table I, of the 103 students who obtained scores in the first quarter on both tests 50% obtained grade point averages of 2.00 or better, 41% of

TABLE I

GRADE POINT AVERAGES FOR THE 1ST SEMESTER 1951 AND 1952 FRESHMEN ENGINEERS IN RELATION TO THE ACE AND PRE-ENGINEERING ABILITY TESTS

	G. P. A.			
ACE and Pre-Engr.	3.0–2.0	1.9–1.0	.9→	No.
1st Quarter on both	50%	41%	9%	103
1st Q. on 1 & 2nd on other	36%	43%	21%	72
2nd Q. on both	14%	56%	30%	57
2nd Q. on 1 & 3rd on other	10%	54%	35%	68
3rd Q. on both	3%	37%	60%	35
3rd Q. on 1 & 4th on other	2%	36%	62%	56
4th Q. on both	0%	18%	82%	55
			Total	446

*Published by the Educational Testing Service, Princeton, N. J.

1.00 → 1.99, and 9% of less than 1.00 whereas of the 55 students who rated in the lowest quarter on both tests 00% obtained grade point averages of 2.00 or better, 18% between 1.9 → 1.0 and 82% of less than 1.00. Although the Pre-Engineering test alone gives almost as good a separation of students at the top, the use of both tests improves the separation at the lower extreme.

Since some students, for various reasons, may miss taking the American Council Psychological Examination, Table II is presented in which rank in high school graduating class converted to centiles is used instead of American Council Psychological Examination. These data were available only for the 1952 group and hence the number is rather small.

The number should, perhaps, be larger if the table is to be used as an expectancy table, although it was found that separate tables for the 1951 and 1952 groups for the American Council Psychological Examination and the Pre-Engineering Ability Test were practically the same.

TABLE II

GRADE POINT AVERAGES FOR THE FIRST SEMESTER 1952 FRESHMEN ENGINEERS IN RELATION TO HIGH SCHOOL RANK AND THE PRE-ENGINEERING ABILITY TEST

	G. P. A.			
H.S.C.R. and Pre-Engr.	3.0–2.0	1.9–1.0	.9→	No.
1st Quarter on both	50%	42%	8%	66
1st Q. on 1 & 2nd on other	19%	58%	23%	57
2nd Q. on both	4%	36%	60%	25
2nd Q. on 1 & 3rd on other	4%	38%	58%	26
3rd Q. on both	0%	56%	44%	9
3rd Q. on 1 & 4th on other	0%	35%	65%	17
4th Q. on both	0%	17%	83%	6
			Total	206

Conclusion

It appears from these data that the Pre-Engineering Test in conjunction with either the American Council Psychological Examination or centile rank in high school graduating class separated the high achieving students from the poor achieving students very well.

It is recommended that such expectancy tables be used to counsel with students early in their first semester in Engineering or before entering when possible either to assist them to gain an understanding of their needs for more effective methods of learning and application of effort, or to transfer to some subject matter field in which they may have higher capabilities. It is not recommended that such data be used alone for the elimination of students from the study of engineering although it might well be used, along with other data, in making decisions regarding borderline cases for admission to a College of Engineering.

Reprints Available . . .

Are you interested in receiving copies of the newly completed "Manual of Graduate Study" or the "Report of the Committee on the Improvement of Teaching"? Copies of these can be obtained from the Secretary's Office, the price of the Graduate Manual being 50¢ and that of the Report of the Committee on the Improvement of Teaching being 15¢ each or $8.00 per hundred. All orders should be accompanied by a check remittance.

Present Limitations and Future Possibilities of Accreditation and Its Effect on the Standards of Engineering Education*

By JOSEPH C. OSBORN

Assistant Professor of Civil Engineering, Montana State College

The report † of the Engineers Council for Professional Development, Committee on Adequacy and Standards of Engineering Education indicates that there is a wide variation between engineering schools of the country in the matter of standards. The report furthermore indicates that the committee is of the opinion that such wide variation is not desirable, and steps to remedy the situation are outlined. The Committee, of course, believes that accrediting procedures must continue, but that they are less effective in achieving the improvement of schools than self-appraisal of schools by their own faculties. I agree that improvement *should* be in response to this impulse from within the school rather than in response to prodding from without. However, suppose that the urge to make a critical self-appraisal is lacking? The report states: "Accrediting procedures relate almost entirely to the minimum standards, and tend to breed complacency among those schools that just barely satisfy such a standard." An attitude of complacency is not conducive to self-appraisal, and those who are complacent may even be antagonistic to the idea that all is not as it should be.

Limitations

The limitations of accreditation are fairly obvious, but should be reviewed here:

First: The accrediting procedure is intermittent. An examining committe may have passed judgment on the curricula, staff and equipment of an institution, and found these items acceptable. Shortly thereafter, a large fraction of the staff of a particular department may have departed, and recruits may have taken the vacant places. Such a change could be for the better, or it could be for the worse, or it could be neutral. If an institution is inclined to frown on those teachers who might make alterations in the existing educational pattern, such a change in staff will probably result in a lowering of standards. In general, if a school has a large staff turn-over, the report of the examining committees quickly becomes out-dated.

Second: Though ECPD makes the final appraisal of a curricula of an institution, the examining committee is a regional committee. If regional differences in standards exist, they would tend to be perpetuated by this procedure.

Third: The examining committee can most easily appraise tangible things such as the qualifications of the staff, and caliber of equipment. It is true that the *potential* standards of an institution are determined in this fashion, but the actual standards are governed by what is required of the student. It is quite possible that a highly qualified instructor may be quite lenient. If an institution does not have a long standing tradition of high standards of achievement required of its students, then, over a period of years, the members of the instructional staff will

* Presented at the meeting of the Pacific Northwest Section, ASEE at Washington State College, April 24–25, 1953.

† P. 249 ff., Jan. 1952, Vol. 42, No. 5, *Journal of Engineering Education*.

consciously or unconsciously conform to their environment.

Fourth: Institutions are inclined to put their best foot forward during the brief period of the visit of the examining committee. This is only human, and I presume that the practice will continue.

There are several things which are conducive to low standards which would not be apparent to the examining committee unless their scrutiny were to be considerably extended. As I have previously stated, standards are determined by what is required of the student. In order to determine what is required in a particular course, it is necessary to appraise the examinations which are given *and the way in which the students exam papers are graded.* If a teacher makes heavy use of the class performance on a quiz in determining the grades the students receive, the appraisal of the standards of the course is doubly difficult.

Information is Misleading

The present accrediting procedure includes an examination of the requirements for admission of students to engineering schools, but here again the information is misleading. Different high schools have widely different standards, and students coming from sparsely populated regions are frequently inadequately prepared in mathematics. If the students who are admitted are poorly prepared, and if the teachers consider the class average in formulating grades, and if the administrative officers of a school appraise a teachers effectiveness by his grade distribution—the combination of these things leads automatically to low standards. Any one of these things alone is certainly conducive to low standards.

When the charge is made that the standards of a particular school are too low, the officials of that school are tempted to counter with a recitation of the accomplishments of a few talented and conspicuous graduates. This, of course, is human, but such a recitation had better be reserved for homecoming banquets. It has very little place in evaluating the caliber of a school. Of course, a statistical study of *all* the graduates is highly pertinent in measuring the quality of a school. However, such data is difficult to obtain, and when obtained, gives only a measure of the school a number of years in the past. In making a present appraisal, it is necessary for us to project ourselves a number of years into the future, and to visualize coming professional requirements.

Another thing which is indicative of low standards is a wide spread between the requirements for the highest and lowest passing grades in a particular course. In other words, a student receiving an "A" grade, or whatever the highest grade may be designated, may compare favorably with a student receiving a similar grade at a school whose standards are high, but another student who received a barely passing mark at this hypothetical school with a wide spread between grades, may be considerably below the passing level at a school with high standards. There are two reasons for the existence of this situation. One is habit, and the other is the scarcity of sub-professional schools or technical institutes. A letter from Dr. H. P. Hammond to Dean Thorndike Saville states the situation clearly: ‡ "I think it is signifieant and important to point out that the number of technical institutes is inversely in proportion to the number of engineering colleges as the need for them exists in this country. Broadly speaking, and with exceptions, they are inadequate also in quality to produce the sub-professional technically trained personnel needed by industry and government. The result is that the engineering colleges are forced to carry a load of what is actually sub-professional training for poorly qualified students who will never become genuine professional engineers. *And many colleges are perfectly willing to do it. This is one of the greatest sources of low stand-*

‡ P. 233, Dec. 1952, Vol. 43, No. 4, *Jour. of Eng. Educ.*

aids of accreditation. It is the reason I advocated the establishment of the sub-committee on technical institutes and this had some benefits, I think, but it has not accomplished what I hoped it might and it never will unless industry, the profession itself, and the colleges get a new conception of engineering as a professional pursuit and of technical institutes as the appropriate source of sub-professional technicians."

Dissimilar Tasks

I am firmly convinced that when engineering schools attempt to perform these two dissimilar tasks—professional and sub-professional training—simultaneously neither job will be done well. Can you imagine a medical school of high repute granting the M.D. degree to poor students who intended to become hospital administrators rather than medical practitioners? I consider it very appropriate for examining committees to scrutinize most carefully the range of knowledge and achievement which a school permits for those students passing a particular course.

Another practice which is inimical to the maintenance of high standards is the practice of permitting students to make substitutions for those courses in their curricula which they have found to be difficult, or which they expect to find difficult. Actually, a student who manages to complete a curriculum in this way is not being graduated from an accredited curriculum, even though there may be nothing on his diploma to indicate that fact.

Conclusion

In conclusion, then, I would like to see the extension of those activities which we have associated with the accrediting process. Perhaps the label "educational counseling" would be a preferable one for the process I have in mind. Possible procedure of operation might be something like this: A national committee for a particular curriculum, mechanical engineering for example, would consist of thirty or forty men who would formulate general policies regarding programs of study in mechanical engineering. This committee would be subdivided into groups of three or four one group of which would visit twelve to fifteen schools in a year, remaining at each school for about two weeks. The process should be repeated every year or at most every second year. The function of this committee would be not only to serve as an accrediting committee, but would be to give direction and unification to engineering education over the entire country. Such a program would be expensive, costing perhaps a half-million dollars a year for a curricula like civil or mechanical engineering. However, this amount distributed to all the schools on the basis of enrollment would not be excessive and I think that the long range benefits to the engineering profession would more than justify the cost.

THE T-SQUARE PAGE

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DEVOTED TO THE INTERESTS OF ENGINEERING DRAWING

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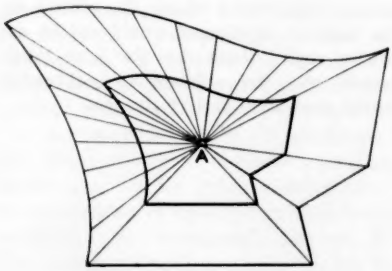
A Construction for Enlarging or Reducing Areas

By ALBERT JORGENSEN

Professor of Mechanical Engineering, University of Pennsylvania

The simple method shown here has many potential uses in the drafting room and shop. For instance, it may be used to enlarge patterns which, for convenience, have been drawn to a reduced scale. Obviously the construction may be used for changing the size of any drawing.



The writer believes the method to be of sufficient importance to warrant its inclusion in basic drawing courses.

In the figure, assume that the heavier lines represent the outline of an area whose dimensions are to be doubled. Point A was chosen at random and through it lines were drawn to significant points on the original outline and then extended an equal distance. The outer ends of these lines determined the outline of the desired area.

Point A may be chosen in any convenient location. Its position affects the location of the resulting enlarged or reduced area.

If it is desired that the two areas do not overlap, it is necessary that point A be located outside the original area.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh		W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	University of Pennsylvania	Dec. 5, 1953	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Library of Congress	Feb. 2, 1954	C. H. Walther, George Washington University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

* **No Date Set.**

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR OR ASSISTANT PROfessor of Civil Engineering. Academic duties: To teach surveying and structural steel design. Appointment date: January 15, 1954. Class instruction begins February 1st. Contact L. U. Rastrelli, Head, Civil Engineering Department, University of Wichita, Wichita, Kansas.

TEACHING POSITION: ASSISTANT Professor of Electrical Engineering starting February 1. Must teach Electronics, Ultra High Frequency and introductory course in Machinery. Master's Degree, twelve-month employment, one-month Summer vacation. Write: K. F. Sibila, Head, Electrical Engineering Department, The University of Akron, Akron 4, Ohio.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Do You Know—

► The first returns on plans for the Annual Meeting at the University of Illinois are coming in. Dr. Richard Burington informs us that the Mathematics Division is scheduling two conferences which will be of interest to those concerned with new trends in mathematics as applied to engineering. One conference will deal with "Problems on Training in the Use of Computing Equipment" and the other "The Place of Mathematical Statistics and Probability Theory in Engineering Curricula."

► Computers will also be featured at a Summer School, sponsored by the Electrical Engineering Division, according to Professor L. V. Bewley. He has arranged with the Bell Telephone Laboratory to have several of their leading men in the computer field prepare conferences and possibly demonstrations on digital computers.

► The Humanistic-Social Division will use their Summer School to launch the new program aimed at an investigation of course content and teaching methods in the social sciences and humanities. This is a study to be financed by a grant of $30,000 from the Carnegie Corporation. Its purpose is to make a comprehensive analysis of curricular programs in those colleges which have given considerable thought to the humanistic-social stem. An advisory committee will prepare its own recommendations at the conclusion of the study.

► The ECAC and ECRC will hold a joint dinner on Tuesday evening, commemorating the founding of the first two engineering research experiment stations at the University of Illinois and Iowa State College. A top-ranking speaker has been invited. The dinner will be open to the Society membership.

► The ECRC is planning its General Session around the theme "Portraits in Creative Thinking." This will feature several persons who have made renowned creative contributions in different fields of activity. They will discuss the thought processes involved in creative thinking.

► The Physics Division is planning a conference jointly with several other ASEE Divisions on the subject of "Contribution of Physics in the Engineering Curriculum." This will provide an opportunity to discuss the desirability of introducing more material in advanced physics into the engineering curricula. It will also consider the problem of achieving better integration of curricular material in physics and engineering courses at the sophomore level. Dr. Seeger, Chairman of the Physics Division, is preparing a program which will include some of the country's leading educators in physics and engineering.

► A number of very helpful criticisms have been received on the Preliminary Report of the Committee on Evaluation of Engineering Education. Many of the criticisms have been directed at the two proposals on accreditation. The Committee is anxious to get constructive comments and criticisms on other phases of the report as well. Each institutional committee which is working with ASEE in this project has received a copy of the Preliminary Report. Also, copies were sent to all deans of engineering colleges. Please send comments to Professor Dan

Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

► The Committee on Constitution and By-Laws has approved the following Amendment to By-Law IV, relating to dues:

"Recommended substitute for present Fourth By-Law:

> Within the ceiling limits for dues hereby established, the dues of members may be adjusted annually by the General Council at the same Council Meeting at which the annual budget is considered. The dues shall be so adjusted within the ceiling limits hereby established that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger continuity of operations.
> The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members. Except for the first year after the adoption of this By-Law, the increase in dues approved at any one time shall not exceed $1.00 for individual members. During the first year after adoption of the By-Law, the dues for individual members will be $6.00 for members who have not reached their 36th birthday by July 1, 1954, and $8.00 for all other members."

► The Society this year has a budgeted deficit of $3,700. Our headquarters staff is seriously overloaded. The Society has three office secretaries for 7,000 members. Our total staff averages one staff member per 1500 Society members. Other principal national societies have one staff member to about 300 to 500 members. We are trying our best to provide the necessary liaison with some sixty Divisions, Committees, Sections, Councils, and Branches of ASEE, as well as to take responsible part in activities of ECPD, EJC, and other organizations closely related to ASEE activities.

► A new Committee on Honorary Memberships in ASEE has been appointed, with President Jess Davis as Chairman. This commitee will make nominations to the General Council of individuals to be considered for Honorary Membership. The Committee will welcome nominations from the ASEE members. This is regarded as one of the highest distinctions which the ASEE can confer on an individual. Recipients will be those who have made major contributions to the ASEE as well as to the advancement of engineering education.

Best wishes for the New Year.

ARTHUR BRONWELL, *Secretary*

On Education, Engineering, and Physics*

By RAYMOND J. SEEGER

Assistant Acting Director, National Science Foundation

It is well to differentiate at the start between engineering and physics per se. Engineering is concerned primarily with the use of knowledge, particularly for problems of design, whereas physics deals with the understanding of things, particularly matter and radiation in their various energetic forms. Of course, there is many a no-man's land between engineering and physics in such areas as fluid dynamics in physics and fluid mechanics in engineering, as physical thermodynamics and engineering thermodynamics, as electronics in physics and electronics in engineering, et al. Recently, however, the picture has become even more hazy by the introduction of the phrase, engineering sciences.. Strictly speaking, one might consider physics as an engineering science. For the purpose of this discussion, however, I prefer to speak of engineering science in this case as engineering physics.[1] Someone has stated that engineering sciences comprise generally those aspects of physics, chemistry, and mathematics that have been abandoned or neglected by the physicists, the chemists, and the mathematicians. Motivation, however, might be considered a more basic principle of differentiation. Thus one may distinguish between engineering physics which discovers in order to know and physics which knows in order to discover, just as one distinguishes between engineering which is concerned primarily with use of principles and physics which is concerned primarily with their discovery. Incidentally, motivation of engineering students for learning physics must necessarily be the responsibility of the engineering faculty. Too often a student with an enthusiastic interest is left to wander aimlessly in the beginning years of his college course. The teacher of physics is frequently called upon to feed engineering students that are not hungry for engineering—and even less for physics.

The question before us, then, is what educational differences, if any, there should be in the treatment of general physics for physics, and of engineering physics as an engineering science, and of physics for engineering. First of all, may I indicate certain basic assumptions that underlie my own conception of technical education?

Basic Assumptions

In the first place, one can look at anything from three different points of view; namely, aesthetic enjoyment, philosophical relatedness, and technological use.[2] For example, one may look at an object in romantic blue light (i.e., if you like blue), in revealing white light (for neutrality), or in far-reaching yellow light (for visibility). Three different educational patterns emerge depending upon which of these viewpoints is of dominant interest. For want of better names, these can be conveniently labeled literary education, scientific education, and engineering education.[3] It is important for us to realize that the expression of the human spirit is

*Address presented at the ASEE Symposium on Modern Engineering Physics at the University of Florida, June 1953.

[1] C. E. Bennett, "Physics Departments and Engineering Physics Curricula," *Journ. Eng. Educ.* **39**, 421 (1949).

[2] A. N. Whitehead, "The Aims of Education" (New York, 1929).

[3] R. J. Seeger, "Whither Education." *Christian Education*, June (1952).

not confined to any one of these educational schemes, but may be found distinctively to the same degree of imaginative insight in each form.[4]

Secondly, although there are three fundamentally different viewpoints for any given object, one must not forget that a single object persists amid the varied lightings. A prevalent criticism of modern educational practice is that it often fails to emphasize this common objective and to achieve unity among the several courses of instruction, or even unity within a single course. It is high time that we scrap meaningless scraps of information, that we no longer pamper college students as adolescent quiz kids boasting incidental factual knowledge. Educational breadth cannot be measured by spottiness regardless of how far removed the spots are from one another, nor does educational quality consist of informational grains of a mechanical mixture regardless of their fineness. Education should rather be integrated both intellectually and spiritually.

A third basic assumption is the need for steady viewing rather than for transitory impressions. Modern general education in any of its experimental forms, as well as the traditional liberal-arts approach, cannot be confined to one or two years of a student's growth. Any point of view must be developed continuously throughout life.

With these assumptions in mind, namely, three different viewpoints—with respect to a common objective—over a long period of time, let us now consider the teaching of general physics in the following aspects: the development of physical concepts, the nature of these concepts, the use of the concepts.

Some kind of general or liberal education is vitally needed as much—perhaps even more so—by specialists than by others. It is just as important that a physicist see physics in its cultural matrix as in its technological pattern. Too often, however, so-called general education consists merely of compulsory courses filled with wonders about scientific facts and with the magic of the scientific method. A truly collegiate approach must be essentially intellectual and, therefore, conceptual. Appreciation of the evolution of concepts is rarely developed owing to a feeling of antiquarianism in view of rapidly changin physical theories.

Creative Imagination

Perhaps the first point to stress here is the use of creative imagination at all levels of expression. In this connection, I have been greatly impressed by the artistic creativity of children. The art itself is exceedingly primitive, but the effort is genuine and interesting. It seems to me that intellectual curiosity and expressive creativity ought to be developable equally well in kindergarten science. After all, the spirit of the kindergarten, the laboratory, and the studio is essentially the same.[5] Of course, if one is going to develop such creativity, one needs relaxation periods and marginal leisure.

It is quite important, moreover, that the role of insight be appreciated in the use of the scientific method and in the development of theoretical concepts. Insight, however, can not be taught; at best, perhaps, its spirit can be taught. In this connection, one might well use case histories involving the development of particular concepts, a sort of inductive approach from the particular to the general.[6]

The evolution of concepts must not only be viewed in their imaginative context, but also be traced in historical currents of thought. The student should be made aware that the phlogiston theory was practised long after the establishment of the conservation of mass by Lavoisier, that the caloric theory was used both by physicists and engineers long after the fundamental idea of heat as a mode of

[4] R. J. Seeger, "Phenomena and Imagination," *Sci. Monthly* **72**, 148 (1951).

[5] E. Schrödinger, "Science and Human Temperament" (New York, 1935). R. J. Seeger, "Our Physical Heritage" (Ann Arbor, 1938).

[6] I. B. Cohen and F. G. Watson, "General Education in Science" (Cambridge, 1952).

motion had been conceived, that Avogadro's hypothesis accepted now as a cornerstone of molecular theory was regarded as incorrect by John Dalton, the father of modern atomic theory, that the relativity theory ascribed by some to the insight of Ernst Mach was actually opposed by him. The historical evaluation of concepts will present the young student with a realistic approach to concepts undergoing evolution in his own scientific world.

Equally significant are the philosophical implications latent in physical concepts at various stages of their development.[7] The simple relationship that force is equal to mass times acceleration has been regarded by some as a definition of force, by others as an experimental law. No wider divergence of philosophical meaning can be found. It envelops completely the intellectual understanding of the concepts involved, particularly, the concept of physical causality. It is necessary for a student to realize the restricted meaning of causality in his scientific work. Then, too, the philosophical implication popularly understood of relativity theory is often in direct opposition to that theory. Of course, all motion is relative to the observer; this fact was generally appreciated by the Greeks and carefully enunciated in the Galileian principle of relativity. The contribution of Einsten was to extract the invariant characteristics independent of the motion of an observer.

The social criteria for the acceptance of scientific theories also must not be neglected; they include many extra-scientific factors. One important factor is common sense which often amounts to the familiar residue of the science of a preceding generation. Another factor is elusive simplicity. For example, the acceptance of the Ptolemaic hypothesis in preference to the Copernican one was due largely to its supposed simplicity. Likewise, the concept of inertia, which appears natural to us nowadays, was so unnatural in the framework of Greek culture that it was ignored there. Physicists today, in turn, are confronted with an increasing number of so-called elementary particles. Up to now, the particle concept has been retained because of its simplicity even though material corpuscles are generally recognized as not satisfying uniquely the definition of a particle in view of their wave-like characteristics under certain experimental conditions. It may well be that the old particle concept has outlived its heuristic usefulness in view of the new complexities that have arisen.

This understanding of the development of concepts from historical, philosophical, and social viewpoints, I believe, is equally important for beginning students whether in physics or in engineering physics or in physics for engineers—indeed, both for scientists and for engineers, as well as for non-scientists.

Let us now consider the concepts per se. With respect to the status of general physics in colleges, one can perhaps remark sorrowfully "too much and too late," as I noted some time ago when I had occasion to review the concepts actually being taught in fluid dynamics.[8]

Physical Concepts

The first question that arises is the selection of physical concepts. Evidently, one cannot treat them all; indeed, in view of their different significances one should not treat all equally. One is forced to select certain primary principles including some recently discovered. In studying these selected concepts one requires firsthand acquaintance with them. There is real danger today, however, that people will become merely arm-chair scientists, content always with secondhand knowledge. Passive observance is insufficient; active participation is necessary. One requires laboratory work for general training in observations and measurements. I doubt if any physics teacher believes he is giving instruction in the complete scientific

[7] P. G. Frank, "Science and Philosophy" (Unpublished notes 1953).

[8] R. J. Seeger, "On Fluid Dynamics in Physics Teaching," *Amer. Journ. of Physics* **21**, 29 (1953).

method through his laboratory assignments. Laboratory experience, however, can assist in clarifying the nature of specific concepts as well as in developing an appreciation of the limitation of their general validity.

It is important also that one views the concepts of a discipline in their entirety, in their inter-relatedness with one another, and in their relatedness with those of other disciplines. For example, the acoustics student should appreciate the relation of impedance to the resistance of the electrical student. The student of mechanical energy should know its relation to thermal energy. In this connection, economy in the organization of thought should be outlined to the student—the presentation must necessarily be largely deductive. This doesn't mean, of course, that the introduction to primary concepts should not be made on a simplified, particularized basis. The engineering physicist and the engineer, above all, should be greatly interested in the organized body of knowledge which permits efficient organization of action.

One must not be content, however, just with understanding a group of selected concepts, with having firsthand experiential knowledge of them, with appreciating the logical deductions that can be derived from them. What is probably most important in a practical world is that a student should be made humbly aware of the limitations of his theoretical knowledge. At all educational levels there should be maintained continually a direct comparison with observed facts. The concepts, in short, should be living concepts, alive in their historical development and alive in their very nature. In this respect, I believe that the physicist and the engineering physicist will both profit by the same approach to physical concepts. The design engineer, however, may rightly be concerned less with the theoretical aspects. Parenthetically, mathematics should be used in all instances wherever it organically affords natural comprehension; it should not be employed as a fetish distracting from the physical truths.

Doers rather than Viewers

It is in the use of concepts, however that a sharper differentiation may profitably be made educationally between the engineer and both the engineering physicist and the physicist. In view of the traditional liberal-arts origin of much of American higher education, it is not surprising that the inertia of Platonic idealism has motivated against the study of useful thinking.[9] You may recall that Plato was not interested in triangles of imperfect materials, but preferred to contemplate the idea of a perfect triangle. Accordingly, his school was more concerned with contemplation than with action. Nowadays, however, we live in a practical world rather than in a theoretical one. We are doers rather than viewers. It is important, therefore, for all students to know how to use concepts, which will become more generally meaningful when used to solve particularized problems. The problems may take one of two major forms: first, problems that promote the understanding of the concepts themselves, and, secondly, problems that deal primarily with the technical use of the concepts. I should like to stress again that a high level of imagination is required to solve both types of problems. It is to be expected, however, that physicists will be more interested in problems of understanding, whereas engineers will be more interested in problems of use. Engineering physicists have interest in both types of problems, but to a less degree in each case. It is possible that physics courses may be differentiated at this point, at least, in discussion sessions. Such courses for engineers can presumably be taught equally well by an engineer with an understanding of physics or by a physicist with an appreciation of engineering.

Advanced Courses

So far, we have considered only college general physics. A few words, in con-

[9] G. Sarton "History of Science" (Cambridge, 1952).

clusion, may not be out of place with respect to certain advanced courses involving several disciplines, usually offered at the junior-senior level. For example, mechanics may be taught in a mathematics department or in a physics department or in an engineering department. So, too, thermodynamics may be taught in a chemistry department or in a physics department or in an engineering department. Electronics may be studied either in a physics department or in an electrical engineering department. It is my personal belief that at this level any student should have as broad a base as possible. Thus it is desirable for an engineer to understand the approaches to mechanics both by a physicist and by a mathematician, as well as by an engineer, and vice versa. To achieve this end a single course might be offered in junior-senior mechanics, a course that would be under the planning cognizance of a faculty committee comprising representatives of each of the three departments mentioned. Such a course could be given by a man in any one of these departments—perhaps, on a rotational basis—provided only that the individuals so selected would have the breadth of interest of all the departments involved. Not only would there be economy in such a procedure, but, what is more, far-reaching educational values. Just as intense specialization within a field begins properly at the graduate level, so, I believe, broad specialization in a field begins properly at the undergraduate level.

In view of my association with the National Science Foundation, it would not be unexpected that I should urge that research and education should be combined to some degree at all levels of college instruction. The spirit of research should permeate even a college course in general physics; some activity of research, indeed, might well be associated with advanced undergraduate courses. The quest for knowledge has always been a race of mankind toward a tantalizing receding goal of truth. The lighted torch must be handed on from generation to generation, from individual to individual. Disinterested curiosity, however, is insufficient in a world of engineering that demands practical action as well as aesthetic enjoyment and creative thought.

College Notes

Beginning in 1954 **North Carolina State College, the University of Florida, Virginia Polytechnic Institute** and the **Southern Regional Education Board** will jointly sponsor cooperative Graduate Summer Sessions in Statistics.

The summer sessions are designed to carry out a recommendation of the Southern Regional Education Board's Commission on Statistics, on which the three institutions initiating the program are represented. They will be of particular interest to (1) research and professional workers who want intensive instruction in basic statistical concepts and who wish to learn modern statistical methodology; (2) teachers of elementary statistical courses who want some formal training in modern statistics; (3) prospective candidates for graduate degrees in statistics; (4) graduate students in other fields who desire supporting work in statistics; and (5) professional statisticians who wish to keep informed of advanced specialized theory and methods. Each of the summer sessions will last six weeks and each course will carry three semester hours of graduate credit, with a maximum of six semester hour credits earned in one summer.

Inquiries should be addressed to Boyd Harshbarger, Head, Department of Statistics, Virginia Polytechnic Institute, Blacksburg, Virginia.

Accrediting of Engineering Curricula*

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee

Twenty years ago the engineering societies began to consider the possibilities of accrediting engineering curricula throughout the United States. The American Institute of Chemical Engineers began in the twenties to examine curricula and accredit them for their own listing. The National Council of State Boards of Engineering Examiners prepared a list before Engineers' Council for Professional Development had set up its procedures. One of the reasons for the organization of Engineers' Council for Professional Development in 1932 was the accrediting of engineering curricula. The Committee on Engineering Schools was organized at the first meeting and then at the first annual meeting of the organization, the Committee reported a procedure by which it proposed to accredit engineering schools. First inspections began in 1935 and by 1937 the inspections were in full force throughout the United States.

During the early days of ECPD, Dr. Karl Compton, then President of Massachusetts Institute of Technology, acted as chairman of the Committee on Engineering Schools. He and his Committee outlined the general philosophy of ECPD accrediting.

The Philosophy of Accrediting

From the very first it was realized that all curricula within the same school were not of the same calibre. It was, therefore, decided to inspect and accredit by curricula rather than by institutions. This decision had a far-reaching effect because it sent the inspectors into the schools not only to look at their general finances, admissions and organization but to actually inspect what was going on within the several curricula themselves. No blanket accreditation was given.

Inspection committees went even further. They inspected the supporting departments of mathematics, chemistry, physics, English, economics, geology, etc. These inspections of supporting departments probably led to some of the criticisms of the inspecting procedure in general. This I will discuss a little later.

Engineers' Council for Professional Development was a conference of five engineering societies: the American Society of Civil Engineers, the American Institute of Chemical Engineers, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners. Later was admitted the Engineering Institute of Canada. These eight bodies have comprised Engineers' Council for Professional Development.

In the early days of accrediting, it was obvious that the curricula represented by the societies should be inspected and accredited. From the very beginning, it was thought that additional curricula should be inspected and added to the list. There were variations of these major fields, such as mining and metallurgy. The question would, of necessity, be raised as to whether these should be accredited as separate cur-

* Presented at the Annual Meeting of ASEE, University of Florida, June, 1953.

ricula or one curriculum. By 1938, sixteen different curricula had been accredited.

It was not long before the institutions began to present such programs as engineering physics, geological engineering, engineering mathematics and geophysical engineering. These programs apply engineering and mathematical principles to fields not normally counted as major fields of engineering. The problem is still before the Education Committee and will probably be solved within the next two or three years.

From the very beginning, it was understood that no curricula would be accredited that were not degree-granting departments in engineering and been in existence long enough to have graduates. As a matter of fact, instructions to the committees are that they inquire into the success of the graduates of the several programs.

What Criteria Are Involved?

The early committee set the general tone of the inspection and accrediting procedure. There must be intellectual atmosphere within the institution. Effort was made not to standardize, but to detect an intellectual atmosphere and climate. The early instructions to an inspector were to avoid giving recommendations which would tend toward standardization. Committee members could discuss problems with the different departments being inspected, but it was not thought good for the inspectors to recommend standardization, number of hours, and other activities which departments should undertake.

It was of paramount importance that there be competent faculty and enough faculty members to insure stability. A one-man department was looked upon with disfavor for the simple reason that if one man left the institution, the whole program might be changed so radically that it would not be the same program which was accredited. Faculty members should show evidence of intellectual activity by their contributions to the technical press, the writing of books, and the preparation of manuals and instructions for their students. It is also considered evidence of good atmosphere if the faculty members were members of their technical societies and took an active part in the American Society for Engineering Education.

The committee realized that there could be excellent faculty members who were not writers or joiners, yet these, generally, were counted as evidence of activity in the field of development of the engineering profession.

There, of course, must be a minimum of facilities, such as laboratories, libraries, etc. The committees were expected to examine the laboratories, look at laboratory reports, laboratory manuals, and student work. They were to examine the libraries, ask the librarian who was interested in books, to determine whether the atmosphere was one of studious application or one in which books did not count.

There must, of course, be ample financial support to protect the institution against lean years or against loss of students. An institution which depends wholly upon student fees was not counted as stable as one which had good state support or adequate endowment.

Inspectors reviewed the content of curricula, going over the whole program with members of the staff, asking questions regarding particular courses—the content, textbooks, types of reports required, etc. It has always been counted very important to discover what was going on in the classroom and the laboratory and the reactions of students to the instruction given them.

Inspectors examined course outlines, examination papers and examinations. They asked for samples of student work showing students' papers with failing marks, with just passing marks, and with good marks. After all, the educational process is for the benefit of the student, and it is the effort of the inspector to determine whether or not the student is growing from a freshman to a beginning engineer at his graduation.

Not only is the inspector interested in the facilities, courses, and so on, but he is interested in what the graduates have done after they have left the school.

Many schools have very good records of graduates' performances. Others have meager records. It happens that at the present time graduates from all institutions are finding excellent employment in industry because of the great scarcity of engineering students.

Who Is Inspected?

Engineers' Council for Professional Development decided early in the inspection procedure to visit only on the invitation of the institution itself. There was no desire on the part of the engineering societies or the National Council of State Boards of Engineering Examiners to go into schools which did not wish to be inspected. The actual inspection was to be made by members selected by the professions themselves. Each member of Engineers' Council for Professional Development, except the Canadian Institute, named a series of inspectors in the several zones of the United States. The chairman of the Committee in each zone normally calls upon the members of his zone to do the inspection. In the early days of 1935 and 1936, the chairmen of committees of all zones aided with the inspections in New England and the Middle Atlantic states in order that there might be uniformity. Uniformity is again insured because the Committee reports are reviewed by the whole Committee on Education.

Visits to the campus are made at the convenience of the institution and the members of the delegatory committees. The chairman of the committee gets in touch with the institution and arranges dates for the inspection. The inspectors spend from one to two days at the institution inquiring into the many matters suggested under the criteria of inspection.

After the visit they make reports to the Committee on Education and it, in turn, reports to ECPD. Work on the Committee on Education is a rather strenuous activity. All reports are reviewed at meetings of the Committee and the recommendations are made to ECPD itself. No delegatory committee or even the Committee on Engineering Education can accredit a program. This is done by the council of Engineers' Council for Professional Development. The whole process is highly confidential. Reports are made only to the Committee on Education and these are counted confidential by the Committee itself. The reporting of accredited curricula in the annual reports of ECPD show only accreditation and not whether it was provisionally accredited or whether it is fully accredited. As far as the public is concerned, a provisionally accredited program has the same standing as a fully accredited program, the only difference being that an inspector is expected to return to the institution after a short period of time to see if the desirable progress has been made toward the full accreditation.

After the findings of the Education Committee are presented to ECPD and acted upon by the Council, the Secretary of ECPD notifies the institution of the action of ECPD. Detailed information may be given by the chairman of the Education Committee or by the regional chairman. Usually, the regional chairman is asked to prepare a letter to the institution if the accreditation is provisional rather than full accrediting. In any case the administrative authority of the institution may ask for detailed information, and it will be furnished by the regional chairman from the reports of the inspectors who visited the institution. Ordinarily, verbatim reports of the inspectors are not furnished the institutions because it is desirable to have the inspector report confidentially to the Education Committee of ECPD. It is not desirable to send derogatory statements to the institution, and it is undesirable for the committee member to include derogatory statements unless they are absolutely warranted.

Accrediting has become so general in the United States where societies and agencies of particular courses are requesting the institutions to receive them to accredit their programs that the colleges have organized the National Accrediting Association which has been examining the general problem of accrediting with the

idea of reducing some of the visits to the several campuses and particularly the tedious questionnaires that are now being required.

At first thought, it seemed possible for some regional agency to accredit the whole institution and thus let this accrediting provide for all the needs of all the agencies needing to know about curricula. After study of the programs of the several agencies the regional accrediting associations which were to do the accrediting as recommended by the National Council of Accrediting has been working cooperatively with such agencies as Engineers' Council for Professional Development to develop procedures which are desirable to get detailed information about courses and, at the same time, avoid great duplication of information by the institutions.

Such matters as financial status, general operation, cost and size of endowment, books in the libraries, work in basic departments such as math, physics and chemistry, might well be inspected once and then not have to be inspected by each professional agency which wishes to get information regarding professional programs.

Cooperative Inspections

At the present time, there is on effort to develop cooperative inspections to avoid duplication. It is probable that within the next two or three years better procedures will be developed. It is further probable that Engineers' Council for Professional Development will continue the type of accreditation that it is undertaking. It is so desirable that curricula be accredited rather than institutions that it hardly seems feasible for one inspection to take care of medicine, law, all phases of engineering, and other professional fields.

The work of Engineers' Council for Professional Development has been outstanding in the field of accrediting. Excellent records have been accumulated. D. C. Jackson in 1939 wrote a report on engineering curricula and determined by the reports of delegatory committees. Much improvement has been accomplished throughout the United States. The problem of fringe curricula is under consideration and will be solved within the next two or three years. The problem of inspection will be simplified during the next few years and, in all probability, it will be generally recognized that the inspections of ECPD are fair and that they are beneficial not only to the institution, but certainly to the constituent bodies of Engineers' Council for Professional Development.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

This Above All*

By E. F. OBERT

Professor of Mechanical Engineering, Northwestern University

The theme of this session, Education *or* Research, is significant in that an entirely different meaning is obtained by changing the *or* to *and:* Education *and* Research. To me, education and research are synonyms for an inquisitive search for the truth. Why this choice of words in the theme? The answer is that a feeling of uncertainty or even resentment is shared by many engineering instructors because of a distinct conflict which exists between the demands of teaching and the demands for published research. Unfortunately, this conflict is not apparent to all observers and my purpose will be to show how it arises and how it can be overcome.

Research

What is meant by research? Every *true* teacher of engineering does research as a normal part of his duties where by research I mean studious inquiry or experimentation leading to previously unknown facts. This research may not lead to publication unless considerable time is spent in improvement and enlargement. The research may even be done in a consulting capacity. But, undoubtedly, this is not the meaning that underlies the theme. Here research implies *published* research and published research implies extensive investigation. One can justifiably argue that only published research can be effectively evaluated. Two other distinctions should be noted: Research may be entirely analytical or else depend heavily on experimentation. It is the latter form which we mainly encounter in the heat power field and, for this reason, our problem is somewhat singular.

Should the engineering teacher consider research to be a part of his job? The answer is an unqualified "yes" because teaching and research are inseparable companions—the research environment is the teaching environment. Should the engineering teacher consider published research to be a part of his job? The answer is again "yes" for a number of reasons: the instructor should have experienced all aspects of research if he is to guide graduate students; the writing of a paper places the man in a position which he may have to defend and so develops his personality; the personal satisfaction of achievement cannot be ignored since it will be reflected in his ego and therefore in his teaching presentation. But now the title of this paper comes into play. Research and teaching are inseparable but published research, *and other activities as well, may* demand time that can interfere with teaching responsibilities. What has been your decision when such interference is encountered? What does your administration do to eliminate the interference?

Duties of the Teacher

Let us list all of the duties or the responsibilities of the engineering teacher. First, of course, we list his teaching assignments if only because we must pay lip-service to this activity:

1) Class work
2) Supervision of courses taught by others
3) Supervision of advanced degree candidates

* Presented at the annual Meeting, ASEE, University of Florida, June, 1953.

4) Supervision of staff employees
5) Counselling students
6) Registration activities
7) Research
8) Committees of the University
9) Committees of the professional societies
10) Student chapter or branch supervision

The reason that a conflict may exist between published research and teaching is not revealed by the items on this list, formidable as they might seem, but between the lines of the list. For example, the class work of an engineering teacher in a large school may consist of only one graduate course plus supervision of a number of graduate students. This man would declare that no conflict exists between teaching and published research. But the teacher in another school may not have graduate assistants and shop help. He must do his own library search in, usually, an inadequate library; he must do his own experimentation and make his own equipment; he must do his own drafting and, in most cases, type his own paper. On top of all this, his teaching load may be excessive. An example was furnished by a friend of mine who quit his post at a large university this year for a job in industry. One semester he had three sections of a three lecture hour undergraduate course; one section of another three lecture hour undergraduate course; one seminar course; one graduate three lecture hour course; one MS and one PhD candidate; and he also had committee tasks for the school. I am aware of many other instances where little time is available for publishing research and for other activities.

It should also be mentioned that there are many teachers who enjoy classwork and committee work but not extended research. I know men of this type who do a splendid job of teaching in all aspects of the work. Unfortunately, however, in this group will also be found mediocre teachers who are interested only in personal activities and those who are afraid to think for themselves. Here the excuse of teaching is used to rationalize the avoidance of research in any form. But if the administration has a promotion policy that demands research, cases of this type would be few.

Teaching and Extended Research

Let us return to the responsibilities of the engineering teacher. Suppose that most of the items on the list can be found on his schedule in whole or in part. Is it still possible to have publications? The answer is a definite "yes" if his graduate school is good, and a definite "no" for the contrary case. Unfortunately, the administration may measure the man in the undergraduate type school with few or no publications and many duties against the man in the graduate type school with many publications and few duties. When this occurs, and it always will with human nature what it is, not much can be done. Even if the administration were to free the man from all teaching duties, progress would not be made for some time. This is because research is becoming big business (and, is this desirable?). A library study that might have taken one month before the war, may now require three months because of the increased volume of publication. Student salaries have doubled and assistant salaries have tripled. I have not seen a good analysis of graduate student cost because such data are difficult to separate from overhead cost. My estimate would be $4,000.00 for each MS candidate (1 year), and $9,000.00 for each PhD candidate (2 years). These estimates are based upon stipends for the student, salaries for the teachers, overhead, materials, and graduate classes of 8 students; the figures can be greatly reduced by doubling the enrollment, ignoring overhead, and including tuition. For examples of costs: IBM calculations for a PhD thesis cost $500.00 in one instance, and the most desirable calculations would have cost $1,500.00; a flow chamber of limited utility (PhD thesis) required 300

man hours of labor, or roughly $900.00. The machine tool investment in a good experimental shop and instrument cost are also items of some magnitude (despite the free gifts of our bountiful government).

There are some who say that the instructor must do extended research as an essential part of his teaching presentation. For the research problem that demands experimental work, I am quite certain that effective teaching would be impaired if the instructor were required to do all of the drudgery associated with the problem. No, the people who claim that such research stimulates teaching have in mind the aftermaths of research—the supervision of research—the culling of ideas for theses—the seminars on related problems—and the consultations between student and instructor.

Research by Decree

Because of the costs of graduate instruction, and because of the drudgery associated with a thorough and complete investigation, a new form of subsidy has appeared: government projects. It is now possible for every teacher to be the guiding genius for a research team. He not only avoids drudgery, but he can time his own hours and therefore set his own paycheck. The quality of his work will be in direct ratio to the quality of his hired assistants. If the farmers are entitled to subsidies, certainly the schools and research are entitled to the same consideration (or are they?).

One other aspect of the publication problem should be mentioned. Is it ethical to place your name on a paper when, perhaps, you did not fully contribute? If the teacher suggests the topic, is he then a co-author? One large research unit has a rule: Do not place your name on a paper unless you are prepared to defend it—odd—I can defend the Bible. Administrations may berate the man without publications, but do they then investigate the unusual circumstances of too many publications?

Conclusions

Although we have selected published or extended research as the offender, it is apparent that other activities can interfere with teaching. It can be concluded in most instances:

1) It is highly desirable for the engineering teacher to do research.
2) It is desirable for the engineering teacher to publish his findings.
3) The administration should have definite policies:
   a) If published research is the keynote for promotion—say so.
   b) If published research is demanded, the teaching load and the pay structure should complement the demand.
   c) If the man who neglects to publish is reprimanded, so should be the man who neglects other responsibilities.

My advice to the young teacher and to the young engineer is to divide his time and therefore his responsibilities in the ratio demanded or implied by his employer. If, because of this division, certain things cannot be done in the manner that they should be done, the remedy is simply the title of this paper.

Stimulation for Study in Engineering*

By J. L. MERIAM

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I. *Introduction*

Engineering education in this country has not been entirely unsuccessful in the past decade or two as is evidenced by the intimate parts which our recent engineering graduates are now playing in all phases of modern engineering development. Despite such evidence of success, a continuing critical review of our philosophy in engineering education is needed. It is perhaps our ready willingness to criticize ourselves which is largely responsible for that measure of success which is ours. The purpose of this paper is to present constructive criticism which bears upon an underlying philosophy of both phases of our overall problem, namely, the structure of our engineering curricula and the teaching which is carried out within that structure. This discussion centers around the psychological basis for learning and thereby attempts to establish the genuine need for including in our curriculum an intimate and continuing contact between the student and real engineering problems with professional implication. It is suggested that this contact be effected through a problem course that would parallel the usual courses in the regular program and that would continue throughout each undergraduate term of study. In this course there would be presented engineering situations of a more comprehensive nature than those considered in individual courses where of necessity the topics and methods covered are of restricted scope. The use of such comprehensive engineering situations is considered necessary for the stimulation of effective study in engineering.

II. *Forces of Learning*

To lay a foundation for proper consideration of the case for a separate and continuing course in engineering problems it is first desirable to examine the nature of the forces that lead to learning. In Barlay's dictionary of 1792 the term "school master" is illustrated with a picture of a small tearful boy standing on a three-step platform before the school master who, with speller in one hand and switches in the other, is extracting the day's spelling lesson from his pupil. The platform is labeled "The Ladder to Learning." The force that causes the small boy's performance is an *inducement* which is clearly the threat of physical punishment and accompanying humiliation. In more recent years pupils have received more humane inducement to learn the conventional school subjects.† After school is over for the day, however, children learn in a very different sort of way. They

* Presented at the Annual Meeting of ASEE, Educational Methods Division, Univ. of Florida, June, 1953.

† The "activity method," formerly called the "project method," is now widely used in our lower schools as a means of inducing pupils to learn the conventional school subjects. The method consists of bringing the pupils into closer contact with these subjects by means of projects and activities which interest them. By and large the immediate objective of this method as used seems to be the mere learning of these subjects rather than the accomplishment of worthwhile activities aided by these subjects. There is an important difference in viewpoint here on the objectives of the method about which educators are in considerable disagreement.

engage voluntarily in activities that are of interest to them and learn to be proficient in these activities at a rapid rate. This proficiency in learning is due mainly to an inner compulsion or *motive* for action stimulated by the interest and meaningfulness of these activities. Adult learning is not unlike child learning in principle—a driving force is needed in each case—and differs mainly in maturity of purpose and in development of power for analysis and synthesis. Driving forces that cause learning activity for child or adult may be identified in two ways as described by the words "inducement" and "motive." An inducement is an external force that leads one on to activity or that moves by persuasion. Inducement is *extrinsic* as the source or reason for action has come from without the individual. On the other hand motive is a force that comes from within the individual and incites him to action. Motive is then *intrinsic*. The small boy struggles with his spelling lesson by extrinsic inducement but learns to play marbles by reason of an intrinsic motive. The different role of each of these two kinds of force in the learning process needs careful study both by teachers of engineering and educators in general. It is the essential purpose here to point out that learning activity generated by *intrinsic* forces is far more intense and fruitful than is activity extrinsically generated. Genuine interest based on inquisitiveness and the desire to accomplish is the spark which ignites intrinsic force and generates a true desire to learn. It is a major responsibility of the teacher to arouse and maintain these interests that in turn generate intrinsic forces of learning. Interest is by far the strongest catalyst for learning.

It would be very revealing if an honest classification could be made of all requirements imposed on and activities expected of the average engineering student during his entire course of study to see whether they result mainly in intrinsic desire to learn or mainly in extrinsic inducement to performance. For instance, are our engineering students aroused in their calculus course to discover for themselves the physical and geometrical interpretation of the integral with the aid of reality in practical application, or are our students induced to study this concept largely as a required manipulation of symbols and exercise in logic? Is the student in basic mechanics presented with interesting problems of practical value that generate a desire on his part to learn about the action of forces, or is he more often induced to equate certain force sums to zero in order to check an answer and to satisfy a required exercise in mental discipline? Do our rigid assignments, formal lectures, and frequent examinations promote activity most conducive to learning, or are they largely inducements to performance? These and other similar questions need honest answers. It appears as though we push our students up "The Ladder to Learning" by inducement considerably more than we stimulate them to climb under their own motive power.

It is not the intent here to suggest that all extrinsic inducement to learning can or should be eliminated. Competition for improved social and economic status provides strong extrinsic inducement which is an integral part of our system and must be accepted. The intent is, however, to point out that learning which arises from extrinsic inducement is highly superficial compared with the more penetrating learning stimulated by genuine interest. Therefore, in seeking to improve materially the education of engineers we should look carefully in the direction of increasing the kind of stimulation that results in intrinsic desire to learn. This can be done by providing from the start of the freshman year an environment of subject matter and teaching which presents a wealth of interesting reasons for technical study.

III. *Doing and Learning*

Up to this point attention has been drawn to those forces which stimulate learning. Such forces, although necessary, are not sufficient to result in effective

learning. Learning may be likened to mechanical work which requires both force and movement. Regardless of the magnitude of the force no work is done without movement. Similarly with learning, the compelling force must be accompanied by action on the part of the learner. "Learn by doing" is a descriptive statement of how we learn. It places emphasis on doing and implies the simultaneity of learning and doing. It is encouraging that recognition of this principle has been given in recent articles on engineering education.

From the standpoint of a statement of objectives it may be pointed out that the saying "learn by doing" should be inverted. The inverse, do by learning, states the objective, which is accomplishment, and describes the means of reaching this objective, namely, through learning. In his book "The School and Society" John Dewey said "Think of the absurdity of having to teach language as a thing by itself. . . . There is all the difference in the world between having something to say and having to say something." It is equally absurd in engineering to teach such basic subjects as mechanics and thermodynamics as disciplines by themselves. In these courses, aided by competent instruction, students will learn how to *analyze* problems such as the rolling wheel and Carnot cycle efficiency. But virtually no attempt is made for the simultaneous synthesis of this knowledge. This synthesis, which requires the understanding of the relationship of the particular tool to the whole of a real engineering problem in which the tool is needed, is a very definite part of the learning of this tool. In reality the need for synthesis in real engineering problems is the main reason for analysis. Inasmuch as learning and doing are basically coexistent, it follows that for the kind of learning with which we are concerned in engineering, analysis should not be taught without ample supporting synthesis at the same time. Doing in engineering involves both.

One often hears it said that our students should receive thorough training in the disciplines fundamental to engineering. Mental discipline in itself is of little or no importance but is a natural consequence of learning how best to reach a goal of engineering achievement. Little mental discipline can be taught until it begins to function in the course of reaching a worthwhile objective. In engineering, doing, in the sense of dealing with real situations, is our objective, and every possible emphasis must be placed on this kind of doing in the preparation for engineering work.

IV. *Need for Motives in the Study of Engineering*

The amount that students actually learn compared with the amount of material covered is an index to the efficiency of our educational system. If such a correlation could be obtained quantitatively, it would, in all probability, be a shock to most of us to see how low it would be. Somewhat qualitatively however, we can measure in our minds what this efficiency is in particular areas. The conclusion we face is that this correlation is far too low, particularly in the first years of engineering study where preparatory courses in science and engineering are undertaken. Let us turn to the principles of learning for explanation. Since learning and doing are basically coexistent can we justify such a large time gap as presently exists between instruction in the basic physical and engineering sciences and opportunity for their use in real engineering situations? Can we justify the present overwhelming predominance of extrinsic persuasion in our curricula and teaching? What objective does this persuasion result in for the student—inquiry and achievement, or merely the passing of next week's examination? Does our present system give maximum encouragement for originality and ingenuity which have been sparked by intrinsic desires? Do we make adequate allowance for individual differences in students? Are our most competent and influential instructors placed

in charge of the introductory courses in which the need for orientation and stimulation of interest is greatest? Unfortunately, the answers to these questions are preponderantly in the negative. There is need for considerable study and action on our part in order that positive answers to these and similar questions may be given.

The design of present engineering curricula has been influenced largely by retrospective reasoning. After a comprehensive grasp of engineering has been gained through study and experience, it is not difficult by retrospection to analyze a field of engineering and line up a logical array of separate courses, physics, mathematics, mechanics, thermodynamics, etc., representing the requisite tools and disciplines of this field. Engineering curricula have come into being essentially in this way and have not been planned adequately to account for the natural process by which most students learn best. In addition to a forceful stimulation of interests this natural process of learning calls for ample opportunity to exercise and expand these interests through direct contact with real engineering problems of sufficient breadth to demand for their solution the synthetic use of the separately studied tools and disciplines. To a certain degree progress can be made to foster interest and integration by effective teaching within existing separate courses. But there is a real need for added opportunity in the form of a sufficiently close contact with selected professional engineering situations of appropriate complexity for encouraging the student to make his own selection and use of tools and methods that are suitable. This need for direct and simultaneous use of the several subject matter tools that are being studied is particularly great in the *first two years* of study which is an important formative period. What is needed in curriculum construction and in teaching philosophy is a planned sequence of experiences and an approach to teaching which fully account for the viewpoint and needs of the learner. The learner's viewpoint is one of anticipation and his needs are for activities which represent synthesis as well as analysis but above all are both purposeful and interesting from an engineering point of view.

V. *Engineering Problems and Projects in the Curriculum*

It may now be stated that effective study in engineering requires (a) the stimulation of interests to produce ample motives, (b) the exercise of motives through doing, and (c) experience in synthesis along with analysis. Thus, effective study is governed largely by intrinsic forces and occurs mainly in the course of doing interesting and purposeful things. Only when these principles are fully recognized are we ready to propose major improvement in our engineering program. The proposal which is offered here to further our approach to these objectives is that we provide ample opportunity during *each* term of the *entire* period of undergraduate study for intimate contact with a variety of real engineering situations that require synthesis as well as analysis. Such opportunity would be in the nature of a separate and continuing course giving interesting professional application to the various separate courses and which might be entitled "engineering projects," "engineering problems," or "professional applications." The course would proceed term by term by bringing the student into direct contact with the demands imposed by real engineering situations, somewhat limited at first but of increasing complexity and with appropriate emphasis directed toward a particular major field as progress in the course of study developed.

The suggestions which follow are offered as indicative of the kind of emphasis advocated. Following an introduction and orientation into the engineering profession as a whole, similar to that now given in most engineering schools, it is suggested that students need some early and direct contact with physical reality in engineer-

ing preferably in the freshman year. Several optional choices can serve for this contact. Surveying, where instrument experience and systematic organization of data are the result, is one such contact. Machine shop, where a feel for the removal and working of metals is acquired is a second example. A course in elementary engineering measurements where such quantities as force, time, temperature, speed, and voltage are measured by the students in conjunction with simple experiments conducted in an engineering atmosphere is a third suggestion. Other possible experiences which would serve to stimulate early interest in engineering among the first year students could be cited.

In the second year of engineering study the student is fully capable of undertaking several simple design projects which follow closely upon his instruction in descriptive geometry, materials, mathematics, and statics. A suitable problem might be the design of a radio station transmission tower. Here the student would be called upon to use the information contained in the subjects mentioned and could further consider some of the associated problems of manufacture, assembly, and cost. The third year student would find that the design of a blower for an air conditioning system, for example, would necessitate his direct use of certain principles of fluid flow, thermodynamics, dynamics, materials, and manufacture. The inclusion of some problems which require knowledge beyond the immediate state of progress of the student can be helpful in pointing out the need for further study. With a background of experiences similar to those suggested here the senior student would be able to handle his design projects with far greater facility than is presently the case. Two or three semester hours of such project work per term would be adequate for the purpose advocated. Before the proposed plan could be put into practice there would be need for much preliminary work by a faculty team to determine the appropriate levels of accomplishment at various stages in each curriculum, the appropriate differences in emphasis for the various fields, the procedure for conducting the course, and to compile a sufficient number of stimulating engineering problem situations.

This suggested plan would offer full opportunity for the encouragement of individual interests upon which true motives depend. When limited to small groups of students individual differences could be accounted for, and originality, initiative, and ingenuity given maximum encouragement. Further, student interests would be stimulated by early contact with activity of a professional character. Also, the opportunity, not sufficiently explored at present, would exist for the student to see immediate practical use for his various tools of engineering. An early demand and challenge would be offered to the student to formulate problems and to select those tools and methods which will yield a satisfactory solution. This type of experience would result in a much needed synthesis and integration of separate courses, methods, and viewpoints. Following closely the instruction in separate fields this problem experience would provide opportunity for a reasonable measure of repetition which must be recognized as characteristic of all learning. Additionally, early experience in dealing successfully with real situations builds individual self-confidence, a quality which far too many of our students currently lack. A further advantage would be the close check on the adequacy of instruction in each of the separate courses as indicated by performance in the project course. Lastly, the results of early contact with professional problems would serve as a valuable indication of suitability for subsequent engineering work and could therefore be used for effective vocational guidance at an early stage. In short, such a continuing problem experience would aid greatly in providing the kind of atmosphere most conducive to engineering study.

This general procedure of using projects in engineering teaching has been re-

ferred to in a number of recent articles in the JOURNAL OF ENGINEERING EDUCATION, three of which are cited here. "The Use of Problems and Instances to Make Education Professional," by B. R. Teare, Jr., vol. 29, no. 3, Nov. 1948, points out by specific example the value of using problems of a professional character in the development of the student. "The Case Method of Teaching on the Senior Level," by J. F. Manildi, vol. 41, no. 10, June 1951, is an excellent description of a comprehensive problem course advocated for seniors where emphasis on the formulation of real problems is given. The recent ASEE committee report "Improvement of Engineering Teaching," vol. 43, no. 1, Sept. 1952, suggests that the "project method" is the most valuable method for developing originality and resourcefulness and advocates its wider adoption primarily within existing courses. In contrast to the messages of these discussions, it is the purpose of the present paper to draw attention to the psychological basis for recognition that this problem or project type of instruction is not only desirable but necessary for the efficient stimulation of learning. Furthermore, it is the purpose here to point out the need for a separately organized and continuing problem course that is offered *simultaneously* with the instruction in separate subjects. It seems to the author that such a plan is preferable to the excessive dilution of individual basic courses which would be the result of inclusion of very many projects or comprehensive problems in these courses.

And now the question of how an additional series of courses can be introduced into an already overcrowded curriculum must be answered. The solution lies in cutting down on the number of separate required courses and particularly the reduction of the excessive proliferation of specialized courses in the senior year. One of our most difficult problems in this age of expanding technology is to maintain an attitude of realism toward the material which can be treated well in four years of study. We must be exceedingly cautious not to promote an excess of superficial knowledge at the expense of true understanding.

VI. *Conclusion*

Present curricula and teaching in engineering reflect practices of the past that were not appreciably guided by study of the educational process. Responsibility is ours for effecting the most stimulating environment possible for engineering study. This responsibility is particularly great when we observe the increasingly active role which the engineer plays in research and development, in business, and in community, national, and international affairs. Discharge of this responsibility requires a realistic reappraisal of our educational philosophy and demands that we give full attention to stimulating those natural forces which result in optimum performance. We can accomplish this in no better way than to establish early and continuous contact between the student and the challenging problems of the engineering world.

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AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1954 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(In Charge of Instructional Division Activities—two years)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

The Student Develops His Tools*

By PHILIP NUDD

Professor of Electrical Engineering, Cooper Union

There is general appreciation of the engineer's work as being creative and productive. Members of our Society have recognized, at least since the 1929 Report on Engineering Education, that the challenge to better teaching is to provide significant student practice in productive and creative work rather than to extend content of factual information. Engineers are well aware that cultivation of an engineering way of approach to a problem, rather than factual information which has been retained, is responsible for their success in new situations.

Teachers are justifiably cautious in placing their faith in new knowledge as being superior to old for the purpose of developing student intellectual power. New engineering tools are welcomed to instruction whenever these tools add power to reason without introducing obscuring complications. New engineering tools and concepts are valuable assets to the learning process if, in addition to strengthening motivation, they are adaptable to student projects. Substitution of content in the curriculum accomplishes little unless the substitution leads to student activity which is realistic preparation for engineering.

Division of the engineering curriculum in terms of subject matter content involves risk that a course will be defined by its informational content rather than by practice afforded the student in developing his productive capacity. Dissatisfaction with the specialized content of some of our courses has led to a proposition that basic science and mathematics should have a larger share of curriculum time. If these subjects are taught in the traditional academic routine there is danger of increasing formalization at the expense of opportunity for teaching engineering. Emphasis on the routine of memorization and testing for retention can fall as short of our objectives as teaching a multiplicity of techniques in the same factual manner in engineering courses.

Emphasis on Content

There has been some resignation to emphasis on content on the grounds that this emphasis is inevitable and productive experience is impractical. It is probably not true that teachers are as addicted to belief in "coverage" of content as their accusers imply. In practice, teachers have had no desire to be negligent in providing productive experience, but there has unquestionably been overindulgence in presenting factual content.

One response to the challenge to provide productive experience has been to introduce a thesis, term paper, course project, or an engineering methods course. These devices are somewhat inconsistent with the principles of learning in that isolated practices do not recognize education as a continuous growth to maturity. An attempt has sometimes been made to correct this defect by inserting the methods course early in the curriculum, or the term paper early in the course, so criticism and experience could guide the student in his later work. A few isolated experiences lead to much the same results as the assumption that students learn written expression only in the English course, and that it is only there that teaching responsibility to develop this ability exists.

* Presented at Chemical Engineering Conference, June 23, 1953.

The principles of learning indicate that a student must experience continuous creative and productive activity on an increasingly higher level to develop his intellectual capacity effectively. Through practice, the tools for reasoning must appear to be an innate part of the individual's character. To merely know of the tools is sufficient for a spectator but not for a creative role.

It is a soundly established principle of learning that lasting values and genuine growth toward maturity of intellectual power only accrue from activity of the learner which is realistically related to his objectives. This principle has directed good teaching toward student centered rather than instructor centered classroom activity. However, we have learned that good teaching, even when student centered, is not enough. Student activity must involve a large proportion of realistic practice in productive work which is significant to engineering.

Students have often obtained more experience in productive work from expression of their reasoning powers in a written report on a phase of contemporary civilization than from an entire science course. Unless student activity involves more than one phase of engineering methods it is intolerably narrow. There should be student activity involving several procedures, such as: interpretation of the problem, collection and coordination of information, consideration of optional methods of solution, and optional recommendations for implementing the solutions. Instruction in anticipation of the problem situation should not rob the student of an opportunity to develop his tools.

It is hardly possible to disagree with the need for student practice in productive work, but we do find wide difference of opinion on the degree to which it is practical to include realistic productive practice in engineering education. The familiar specious arguments are advanced that it is necessary to "give" the student some factual knowledge before he can be placed in a problem situation, or that mathematics cannot be taught by the project method, or that a student can obtain productive experience better in another course. Although projects must be adapted to previous experience and degree of student maturity, they may be devised as readily to introduce the first chapter of the first course as the last. If students or instructors must be won over to this type of instruction, projects need not be ambitious, and they need not be the only method for learning, but there must be sufficient projects in every course for mutual support.

Well Designed Project

A well designed project will send the student to his text or other sources for the information which is to be developed. He will read and evaluate with a purpose and direction consistent with the principles for learning. His rejection of material will develop as important a tool as his acceptance. A combination of existing information and materials will be required in a form which is new and original to the student constructing the product. New tools of the profession may be introduced to provide motivation. When these new tools are introduced projects may be proposed in a form to send the student after elements of the new concept and to make it unnecessary for the instructor to squander the student's time by imparting extensive information on refinements of advanced techniques. If specifications for the project are open-ended, there is opportunity for the student to develop his judgment of relative value and capacity.

Students must be on their own to develop their will and capacity to walk alone. Instructor assistance should be on an individual basis, and should be given only when it is sought by the student. The instructor should then help the student to help himself discover how to work, rather than supply information or solve a detail of the problem situation. Written presentation must be of sufficient length to cause the student to develop his tools for coordination and reasoning. The student's presentation should be reviewed and criti-

cised with at least as much attention to the way he worked and the style of his presentation as to technical details of the problem.

For more than a decade it has been the policy of the Electrical Engineering Department at the Cooper Union to urge instructors to do no lecturing, to hold explanations involving the whole class to a minimum, and to make a maximum number of assignments in a form requiring the student to make a written presentation of considerable length. It has been the objective to involve optional interpretation of the problem, optional methods of solution, and optional recommendations to be derived from the work. Instructors are urged to curb their impulse to provide information in anticipation of the work assignment, or to give assistance before the student has had opportunity to respond to the challenge to extend his intellectual power by developing efficient conditioned reactions through a normal experience of floundering. We have considered our classes to be two- or three-hour work sessions, very similar to the universal practice in freshman engineering drawing. Evaluation is on the basis of work submitted rather than on examinations.

Convictions

From our experience with these teaching methods we have derived several convictions:

1. In spite of all handicaps, this method of instruction is superior to a routine of class discussion, oral explanation, and one-page problems.
2. At least an equal amount of durable information is acquired by the student through this method as compared with methods which emphasize imparting information and testing for retention.
3. The wider the student's experience with this method, and the larger the per cent of his simultaneous experience in it, the more efficient is his development of engineering power.
4. It is possible and important that these methods be a part of all courses from the time the student enters college.
5. The student is troubled by three initial handicaps:
   (1) The student has not had adequate experience in written presentation where coordination and integrity of his arguments were essential to worthwhile conclusion.
   (2) The student has not discovered that a written record is an essential and powerful accompaniment to extended reasoning.
   (3) The overwhelming volume of the student's experience in playing school has conditioned his attitude to the point where he does not expect his education to be a realistic practice for engineering.

We have accepted the concept that final reliance must be placed in the teacher to develop his own teaching procedures, but to make these a significant part of the whole he must not ignore the necessity for coordination with the total program for intellectual growth. There has been some country wide sentiment to the effect that the teaching situation should be altered so instructors would not be able to prevent student self-learning. This may prove to be a desirable solution.

Effective learning should not be obtained at the expense of overburdening the instructor. It should not be assumed that realistic student practice necessarily demands more of the instructor's time than other procedures which are not abused. Initial efforts do require motivation and incentive for the teacher. These can be provided through appreciation from his students, and through recognition of effective teaching as the only important requirement for promotion within the teaching salary scale.

Aims and Content of Engineering Economy

By ARTHUR LESSER, JR.

Professor and Head of Industrial Engineering, Stevens Institute of Technology

Because of the general misunderstanding as to the aims and content of engineering economy, it is pertinent to review the literature on this subject as the first step in this analysis.

Most striking is the concentration of writers on financial mathematics, notably on the concept of compound interest involving long-run comparisons of capital goods investments. Some apparently believe that compound interest formulas and engineering economy are identical. "Engineering Economics and Practice" by Steinberg and Glendenning,[1] a book based on the New York State Professional Engineering Examinations,[2] is exclusively devoted to compound interest comparisons.

Arthur M. Wellington's book on the location of railways [3] is generally accepted as the historical classic in the field of engineering economy. He postulates that railroads were not built for the traffic immediately available upon completion. Plans were generally made for an expanded future traffic which, from available records of completed lines, would presumably increase on a compound interest curve. Thus if a bondholder invested $1 in a railroad, he could expect to earn a compound interest return. Wellington cautioned that it was not safe in making computations to assume compounding of traffic much more than three years in the future—certainly no more than ten years. He recognized that railroad traffic was sensitive to the business cycle. Since he knew that railroads were financed almost entirely by fixed interest securities, he reasoned that the railroad company stockholders, who usually had no actual monetary investment, would lose control because of bankruptcy, if they extrapolated the traffic curve too far into the future. Obviously the heavier the anticipated future traffic, the greater must be the initial investment in physical facilities. This in turn meant higher fixed charges. Wellington further warned that such compound interest rates were "of value only as fixing a maximum which should never be exceeded." [4] He believed that income from railroads, unlike other businesses, could under no conceivable circumstances be destroyed because of the monopolistic nature of the railroad.

In determining the justifiable total investment, Wellington perceived it was important to apply the compound interest concept within the practical limits dictated by the peculiar circumstances surrounding railroad building of his day. When it came to deciding between alternative lengths of line or curvatures in the line, Wellington assumed a perpetual life. Thus he simplified his computations by making it possible to use the capitalized cost method at an assumed or actual rate of interest. Wellington was not troubled by shifting his assumption of a short finite number of years for the total investment to an infinite number of years for portions of the whole. He probably would have justified this shift by saying that the monetary calculation was only a guide for making decisions, and not the most weighty factor. He was careful to point out, particularly to young engineers, the need to weigh every other relevant factor. Wellington was a practicing engineer whose book was a guide for other practicing engineers.

Chronologically the next important book was "Engineering Economics," [5] by Fish of Stanford University, also a man with a

railroad background. His second completely rewritten edition in 1923 has proven more significant than the first edition published in 1915. Therefore I shall discuss only the 1923 edition.

Business Side of Engineering

Fish took an entirely different approach which has been substantially followed until this day. He wrote from the standpoint that "the engineer's professional success and contribution to public welfare depend in a great measure on his understanding of the business side of engineering—of engineering economics." [6] As early as 1897 Alexander C. Humphreys, later President of Stevens Institute of Technology, also preached the need for engineers to learn business methods.[7] Humphreys' view of economics of engineering was broad, encompassing what might today be called industrial management. Fish's concept was that engineering economics was a financial matter based on the choice of investment, rather than on the choice of structure, i.e. anything from a building, machine or road to a plant.

When Fish decided the central problem of engineering economics was investment, he looked to the Wall Street bond market for his prototype or model. He envisaged the capitalist as choosing between investments in alternative structures just as the same capitalist would choose between bond investments. By using what I shall hereafter call the bond market analogy or model, Fish transferred the emphasis from the engineering considerations of Wellington to financial considerations. His book is an introduction to the field of investments stemming out of engineering structures rather than security issues.

Fish looked upon the investment in a structure as the purchase of a capital asset. The life income of this asset would pay all costs of operation and amortize the capital cost, leaving a yield or return on the original investment. The annual operating costs and income are to be computed as hypothetical equivalent uniform payments, or, under certain conditions, yearly averages. Depreciation is to be computed on an invested sinking fund basis. Presumably the analogy between investing in a bond and an engineering structure is close.

The bond buyer purchases a set of future expectations. These consist of a specified number of semi-annual coupons of a stated amount which are good on their respective dates, an annuity certain. In addition, the buyer expects the return of the original investment, if purchased at par, at the maturity date of the bond. According to Fish, the potential investor will buy a bond or alternatively a structure, if the qualities of the investment, including yield, compare favorably with an imaginary set of qualities in the investor's mind—qualities that pertain to the least advantageous opportunity he believes acceptable to him. For situations where income is considered equal, yearly costs of alternatives are compared and differential cost is compared with the differential investment to determine yield.

Bond and Structure Investment

Fish satisfied himself that there was a close correspondence between the concept of bond investment and structure investment. His book does not analyze the correctness of this deduction. Since he dealt primarily with structures where the future is less difficult to forecast, his analog may be appropriate. On the other hand, experience has shown that his restricted financial approach, which set the pattern for many years for subsequent writers, has been a handicap to the full development of engineering economy. It has led some to assume that engineering economy and the bond market analog are the same. Others have applied bond market model indiscriminately whether the assumptions underlying its applications have been fulfilled or not. Emphasis on the financial side has resulted in many instances either in virtual exclusion of other considerations, including engineering, that are not reducible to dollars. However, it should

be noted that Fish did introduce irreducible factors in his analysis. But these factors were chiefly concerned with financial considerations that would be of interest to the bond market investor and not to the engineer making a decision.

Also in 1923, Goldman's "Financial Engineering" [8] appeared. Goldman, like Fish, felt the second edition of his book was superior to the first edition published in 1920. Goldman said, "there are primarily two divisions to our entire problem, namely, cost segregation and cost analysis, as applied to (a) cost determination and (b) design for best economy." [9] Goldman devoted himself exclusively to investments in long term assets such as motors, engines, pumps and facilities used in power plants. He leaned heavily on compound interest calculations for purposes of comparison. Goldman provided data on operations and costs of equipment. However, he dealt only with financial considerations and not with those factors that could not be reduced to financial terms. Evidently he desired to provide "a definite, scientific method of determining the comparative value of all things which he (the engineer) must use and the value of systems and of investments in general." [10] Goldman completely neglected to mention the limitations of his methodology. One can understand how he might have led his readers to believe that financial engineering was a special kind of engineering where certainty reigned.

I do not believe it was an accident that both Fish and Goldman emphasized financial considerations. They both wrote in a period when the investment markets were pivotal in our economy. In a sense, survival and expansion were based on whether financial help could be obtained from investors through organized markets. Now Wall Street is no longer in a commanding position. Due to internal financing some business enterprises have found it unnecessary to resort to outside investment sources for funds. Thus financial considerations, as exemplified by the investor viewpoint, have substantially given way to production or marketing considerations. As a result we must ask ourselves, "Has thinking in engineering economy kept pace with this fundamental change of conditions?"

Following in Fish's footsteps, Grant published his text in the engineering economy field in 1930.[11] Grant realized that Fish's preoccupation with the concept of engineering economy as synonymous with bond investments was not sufficiently broad. Grant advanced beyond Fish. He introduced comparisons which did not involve long term investment comparisons. He devoted an entire section of his book, Part II, to factors of judgment, enlarging their scope from the irreducibles of Fish which included little more than considerations involving bond investment. He showed the weakness of using capitalized cost comparisons. He indicated that statistical methods would be valuable in engineering economy studies involving sampling. (Two decades later Grant attacked this problem in the second edition of his "Statistical Quality Control." [12]) Grant pointed out in his section on Review Problems that the textbook problem generally oversimplified the technical facts. This gives an inadequate picture of the difficulties encountered by an engineer when confronted with an actual problem of economy. Unfortunately, it became the fashion to feature simplified problems. Thus they became merely exercises in arithmetic, omitting the real challenges in engineering economy work.

Interest on Capital

Grant accepted the bond market model and put most of his emphasis on using it. But he did not give consideration to the model until his second edition appeared in 1938. For example, he indicated that there was real justification in engineering economy for using interest on capital rather than just using it as a convenient means to make comparisons involving time. However, the crucial question is whether the computation method is appropriate under the circumstances. Grant

also proposed that compound interest calculations giving exact comparisons were often unjustified in practice because of the unreliability of estimates. He felt simplified solutions using average interest over the estimated life were often just as good in practice as more time-consuming compound interest computations. However, for theoretical work Grant returned to the bond market model with appropriate modifications. He considered the popular short payoff or capital recovery period as a means of introducing a safety factor, albeit of unknown magnitude.

Rautenstrauch, who as early as 1907 gave a course in Works Management for engineers at Columbia, published "The Economics of Business Enterprise" in 1939.[13] He incorporated the usual engineering economy techniques in his analysis of the economic characteristics of industrial organizations. These characteristics, consisting of the relationship between income and expenses, were revealed by the now familiar break-even analysis which Rautenstrauch introduced. Thus Rautenstrauch stands somewhere between Fish's viewpoint of engineering economy as a problem of investment and Humphrey's viewpoint of engineering economy as encompassing the field of industrial management.

In 1942 two new texts on engineering economy appeared, one by Bullinger[14] and the other by Woods and De Garmo.[15] Both were designed for undergraduate students. The real difference between them and their predecessors was one of emphasis, and, to a certain extent, approach. Bullinger emphasized the importance of intangibles in arriving at a decision. He would settle for the best attainable or optimum results considering all factors. Woods and De Garmo favored the more restricted, least cost criterion using the bond market model.

Dynamic Model

In 1949, Terborgh published his "Dynamic Equipment Policy."[16] Terborgh's primary interest is in replacing industrial equipment, notably machine tools. Hence his methodology is not a general treatment which can be used indiscriminately in any situation.

Terborgh points out that many types of capital goods during their life time do not continue in the service for which they were originally intended but are "kicked downstairs" in the scale of service. He rejects the customary static model of comparing a piece of equipment already performing a certain function with a challenger, a piece of equipment new at the time the analysis is made. He creates a dynamic model wherein he compares the defender with equipment yet unborn. Thus he introduces an estimated amount of obsolescence as compared with the usual guesswork in respect to the obsolescence factor, if it is considered at all. Terborgh's chief interest is in developing a formula so that quantitative monetary comparisons can be made. He is careful to say that results obtained from using his formula are not final but a first approximation with the ultimate decision an act of judgment.[17]

He uses the compound interest method for the recovery of capital in developing his theory. Like Grant, he says that a sufficiently good approximation is available by using simple averages rather than the more exact compound interest computations. He develops his formula accordingly.

Terborgh is particularly critical of the short pay-off requirement as a means of deciding among alternatives. He says the short pay-off period results in the undue prolongation of the life of existing installations by requiring the next year's advantage of the challenger over the defender to be inordinately large. This puts a protective wall around the defender until it is much past its usefulness. In addition, this criterion carries with it implicitly the notion that the only desirable replacement is that which meets the short pay-off period. But there may be many reasons of equal or more validity, such as demands of competition or of safer opera-

tion. Terborgh also takes to task the rate-of-return or yield on investment requirement, a corollary of the short pay-off period. He also criticizes the minimum-average cost formula—the bond market approach.

This book ends with the thought that American industry in appraising replacement needs has had nothing better to work with than folklore and superstition. Terborgh's chief contribution has been in revealing the assumptions and weaknesses of the accepted procedures in the field. However, the alternative he suggests is not the complete answer.

During 1950, the same year when Grant's third edition appeared, Thuesen's "Engineering Economy" was published.[18] Thuesen's major contribution is broadening engineering economy to include the consideration of questions involving manufacturing operations where time is not a variable. In Chapter 15, "Economy of Operations," he takes up the economical size of repair crews, and economic loading of equipment. He also suggests the use of input-output analysis which leads to the idea of optimizing output given certain inputs into the system.

Impact of Income Taxes

Grant in his third edition, turned attention to the impact of income taxes on engineering economy studies, in addition to embodying the material covered in his second edition. And, in Chapter 20, he gives a review and critique of some of Terborgh's ideas.

It is evident that the writers have been most concerned with the techniques of analysis rather than the nature of engineering economy, perhaps because most of the books were designed as texts. But what can be said of these techniques? Are they useful? Are they adequate?

First, they are quantitative. Usually, but not always, they have a saving clause to the effect that the monetary analysis indicates the direction of solution only, and not the final answer since all variables cannot be quantified in monetary terms. We can rationalize this approach with the observation that it is the best that can be done in teaching undergraduate students. However, this explanation is not adequate when considering engineering economy as a discipline or as an important tool for practicing engineers. There is a real need for a technique which will incorporate all relevant variables in each problem.

One approach worth exploring would be to require the student to indicate in each situation what the relevant variables are. Perhaps he can do this with the aid of a check list, even if he cannot evaluate them all. Even more fundamental are problems of broader scope than are generally available at the present.

Second, some of the techniques like the short pay-off period or return on investment, are little more than rules of thumb. Those techniques involving financial mathematics, notably compound interest—the bond market model—are almost entirely academic. It is generally conceded that a large portion of industry, other than the public utilities, does not use compound interest calculations. Many firms in fact do not use interest in their calculations. Is industry wrong or are the academicians wrong in urging this approach?

One answer may be that if industry does not accept the technique there is little justification in giving it more than passing notice. Or alternatively, we may take the position that the technique is inherently sound and deserves the emphasis it gets. However, saying that the technique is sound does not make it so. The time has come for the technique to be evaluated particularly in reference to its verification in practice. If it is found to be a useful and valuable tool in public utilities and public works but not in manufacturing, then it should be so stated. If it is found to be of little use as an analytic tool in any context, this fact should be admitted. In an eminently practical field like engineering economy, theoretical solutions which have little or no semblance to real life have little justification.

The nature of the data used in engineering economy studies is a subsidiary aspect of the techniques themselves. Text book writers in the field agree that the principal data are furnished by accountants. Therefore it follows that, for those who are expected to use engineering economy techniques in practice, only the customary brief look at these fundamental data of engineering economy is not enough. This is especially so now that some companies are using data derived from standard cost studies. The potential role of statistical techniques in engineering economy studies also needs to be looked into more deeply.

Philosophy of Engineering Economy

Valuable as techniques are, they are not enough for a discipline. We must also know in what direction the discipline is going to be sure the techniques are the proper tools for the discipline. The literature does not give any crystallization of thought on the nature or philosophy of engineering economy. But portions of it pieced together in broad terms reveal that:

1. The principal objective of engineering economy is to aid in making decisions between alternatives arising out of engineering work.
2. The role of engineering economy is to develop a framework and to create techniques within this framework which techniques will be of practical significance to resolve actual problems.
3. The framework consists of the following major points:
   a. Engineering economy embraces the study of all factors of variables which enter into a choice among engineering alternatives. (Restricting engineering economy analysis to the factor of monetary cost alone presupposes that this factor is the controlling variable.)
   b. Relevant factors or variables should, as far as possible, be expressed in terms of monetary costs and revenues in order to minimize the judgment area for final decision-making in respect to those variables which cannot be expressed in monetary terms. (If all variables could be expressed accurately in monetary terms, the resulting quantitative analysis would indicate immediately the preferable choice.)
   c. Since all relevant factors or variables cannot either be minimized or maximized at the same time the result sought should be an optimum relationship among the variables. (For instance in a public utility, cost of service cannot be minimized at the same time the elements entering into service to customers is maximized.)

Based on this framework, it is not surprising that some texts on engineering economy have included some subjects and not included others. The authors confine themselves to the variables they think should be given most attention within the limitations of a book.

Proposals

This is a sound framework. But neither implementation through the techniques nor the techniques themselves are entirely adequate. Therefore, I make the following proposals in broad outline:

1. Studies should be conducted on Engineering Economy as a discipline and on the techniques themselves.

2. A subcommittee of the Engineering Economy Committee should be established, initially for a two year period for these purposes.

3. Through ASEE an effort should be made to obtain financial backing.

If the above suggested program is adopted and carried through vigorously and imaginatively, engineering economy can become a more live, dynamic subject.

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3. Arthur M. Wellington, "The Economic Theory of the Location of Railways," John Wiley, New York, 1887.
4. *Ibid.*, p. 85.
5. J. C. L. Fish, "Engineering Economics," Second Edition, McGraw-Hill, New York, 1923.
6. *Ibid.*, p. V.
7. See Alexander C. Humphreys, "Lecture Notes on Some of the Business Features of Engineering Practice," Stevens Institute of Technology, 1905.
8. O. B. Goldman, "Financial Engineering," John Wiley, New York, 1920.
9. *Ibid.*, revised edition, p. 6.
10. *Ibid.*, p. V.
11. E. L. Grant, "Principles of Engineering Economy," Ronald Press, New York, 1930.
12. See E. L. Grant, "Statistical Quality Control," Second Edition, McGraw-Hill, 1952, Chapter XVII.
13. Walter Rautenstrauch, "The Economics of Business Enterprise," John Wiley, New York, 1939. Also see the successor volume—Walter Rautenstrauch and Raymond Villers, "The Economics of Industrial Management," Funk & Wagnalls Co., New York, 1949.
14. Clarence E. Bullinger, "Engineering Economic Analysis," McGraw-Hill, New York, 1942. A second edition appeared in 1950.
15. Baldwin M. Woods and E. Paul De Garmo, "Introduction to Engineering Economy," Macmillan, New York, 1942. A second edition is scheduled to appear in 1953.
16. George Terborgh, "Dynamic Equipment Policy," McGraw-Hill, New York, 1949.
17. *Ibid.*, p. 134.
18. H. G. Thuesen, "Engineering Economy," Prentice Hall, New York, 1950.

College Notes

The **Pan-American Federation of Engineering Associations** (UPADI) will hold its Third Convention in Sao Paulo, Brazil, August 3 to 13, 1954. The time was selected so that engineers might attend both the UPADI Convention and the World Power Conference. Anyone interested in learning more about UPADI or the Sao Paulo Convention may secure information by writing to UPADI, Box 40, Midtown Station, New York 18, N. Y.

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Program plans for the 1954 annual short course in corrosion held by the National Association of Corrosion Engineers are well under way, according to Dr. M. F. Adams, N.A.C.E. program chairman and associate chemist, Division of Industrial Research, **Washington State College.** The five-day course to be held on campus of Washington State College at Pullman, February 1–5, 1954, will present a brief but intensive review of the fundamental aspects of corrosion followed by panel discussions and lectures on the applications of corrosion control in industry. The Division of Industrial Services of the Washington State Institute of Technology is the college sponsor of the course.

The program includes five general topics—fundamentals, practical aspects, corrosion mitigation, materials of construction, and environment.

For further information address requests to Professor E. B. Parker, Director, Division of Industrial Services, State College of Washington, Pullman, Washington.

Should Residence Credit Requirements be Retained?*

BY GEORGE B. HOADLEY

Professor of Electrical Engineering, North Carolina State College

In recent years, much pressure has come upon engineering graduate schools to make graduate training available to the employees of industry as an out-of-hours program. In the large industrial centers this demand has been met by late afternoon or evening courses. In fact, some institutions such as the Polytechnic Institute of Brooklyn have based their reputation in a significant measure on highly successful programs of this sort. But in some situations, evening courses are not enough to meet the demand. Industries and government installations located some distance from college campuses see advantages to them in proposals to bring the professor to the students by having courses taught at the plant or laboratory rather than on the college campus. The distances involved may range as high as 100 miles, so travel time and cost become significant factors. Such proposals can usually meet the existing college regulations regarding degrees in all but one respect, the residence credit requirement. To the enthusiastic supporter of an off-campus study plan, this requirement seems like a "gimmick"—a requirement with little real significance used by the authorities to block progress, and put in the regulations originally because some other more prominent school had such a requirement.

On the other hand, the proponent of the classical full treatment for graduate students views the residence requirement as being a protective bulwark against unwise proposals, fully justifiable in terms of the academic experience it insures to the student beyond the formal attendance at classes. The gulf between these two viewpoints is indeed wide, and when different groups in the same college espouse these different views, it becomes imperative that each should study carefully the viewpoint of the other before final decisions are reached regarding off-campus work. I shall try here to explain briefly several viewpoints regarding residence credit without going into any of the other aspects of the off-campus course problem which may be really serious to an administrator but which do not concern the student.

Equivalent Facilities

The first value claimed for the residence requirement is that it makes the facilities of the college available to all students. Usually such items as classrooms, laboratory equipment and library resources head the list of facilities. However, the doctrine of "equivalent facilities" soon arises, and the college may well find itself embarrassed by the unfavorable comparison between its own facilities and those offered by the organization requesting the off-campus work. For example, I have taught in college classrooms where half of the seats in the room were unusable because of glare from the blackboard.

Of course the college should assure itself that satisfactory facilities are available if off-campus courses are offered. But there should be no middle ground

* Presented at the Annual Meeting of ASEE in the joint session of the Graduate Study and Evening Engineering Education Divisions, Univ. of Florida, June, 1953.

where facilities are not good enough to give full credit for a degree but yet are good enough to allow a course to be given. If such is done, it is an admission of a venture into substandard work.

One other point regarding laboratory and library facilities is worthy of mention. There is a vast difference in the requirements between courses. Some courses require no laboratory at all, and the library requirements vary from course to course, so the adequacy of facilities must be determined individually for each course.

Other matters which must come in for discussion are the quality and level of the work, and the teaching ability of the person giving the course. All of these factors must receive careful attention before an off-campus graduate course is offered, but once it has been determined that the course will be truly of graduate calibre, it should be fully accepted as such.

The program comprising such courses will be restricted to the courses offered, so may not be as well suited to the particular preference of each individual as would be the case in an on-campus program, but it will meet the interest and needs of most of the off-campus students. Thesis requirements for the degree can be met by a project carried out under the supervision of a faculty member at either the off-campus location or at the college. Different colleges have diametrically opposite views on this point. Either method can be made to work effectively.

At this point in our thinking we have reached the view that if a course is of graduate calibre, it matters little where it is taught, so that on this basis the residence credit requirement has no meaning except to insure that an adequate proportion of work is taken under the auspices of the college granting the degree. If no other ideas are involved, residence credit is an unjustifiable requirement and should not be retained.

Broader Concept

There is, however, a broader concept of graduate training which has been most excellently stated by Dean Hazen and his associates in the M.I.T. Graduate School Manual, issued January 1953. I recommend this pamphlet to all of you who are concerned with the problems of graduate education. The essence of this viewpoint is that true graduate study is an educational experience in a community of scholars without the distraction of a job being held at the same time. This experience requires the undivided attention of the student to the problems of study and research, with ample opportunity for real association with "able men under the stimulus of intellectual competition with associates."

Such a concept of the residence requirement does not completely eliminate off-campus work since some non-college research laboratories do maintain the intellectual atmosphere in their daily work. At such locations, off-campus work could be approved, but most development laboratories and industrial plants would be excluded.

Two Types of Degrees

There is a real need in America today to bring additional study to people in industry. In agriculture this has been done via the extension worker, and the college authorities proudly proclaim that the college campus covers the whole state. In engineering we are in a different situation because the people we wish to reach in this effort are already college graduates and to them the possibility of another degree is part of the incentive for advanced study. Therefore, I propose that two types of graduate degrees be generally accepted throughout the United States. The first of these is the Master of Science, a degree awarded only to those who experience the full educational experience of undistracted association with intellectual peers in an atmosphere of academic quality. The second of these is the Master of Engineering, a degree awarded to those who complete a satisfactory program of advanced technical work and who show evidence of ability to take the initiative

in the solution of a technical problem, such as a thesis problem.

If we can generally agree on these two types of degrees, we retain the strict residence requirement for the first and dispense with it for the second. This gives a framework for each type of operation, and the prospective graduate student can select his school and his program to suit his desires. But here we need a directive to catalog writers. If residence credit is required, its justification should be explained to the prospective student so that he can really understand the difference between a program with such a requirement and one without it.

Present Status of the Japanese Society for Engineering Education

By KINJI SHIMIZU

Managing Director of JSEE
President, Nagoya Institute of Technology

The American-Japanese Conference of the Institute for Engineering Education held in the summer of 1951 was a great impetus for the improvement of the Japanese Engineering Education. As the result of discussions at the meetings extending 2 months, Japanese engineering teachers and industrial representatives decided to organize a Society for Engineering Education in Japan, such as ASEE in America.

Japanese engineering education having about 60 years' experience had no organization where improvement or development of the education should be discussed or engineering teachers should criticize their teaching with each other. The aim of the society we were to organize was to discuss freely the ways for improving and developing engineering education on the one hand and to realize, on the other, the cooperation of engineering teachers and industrial engineers for its promotion.

Dr. Shimizu spent considerable time in America gathering ideas concerning engineering education, including three months at the Technological Institute of Northwestern University.

After several meetings from November 1951 to March 1952, held by nation-wide representatives, it was decided that seven regional societies—Hokkido (Sapporo center), Tohoku (Sendai center), Kanto (Tokyo center), Tokai (Nagoya center), Hokuriku (Kanazawa center), Kansai (Kyoto and Osaka center), Kyushu (Fukuoka center)—be established at first and then their federation, the Japanese Society for Engineering Education be organized.

By the middle of July, all 7 regional societies started and we held the inauguration ceremony of JSEE on August 7 at the Japanese Engineer's Club, Tokyo. Miss Snavely of the Unitarian Service Committee, attending the ceremony, read the message of Dr. H. L. Hazen, the chairman of the American Advisory Mission to Japan for Engineering Education 1951, and that of President W. R. Woolrich of ASEE, both of which made deep impressions on the audience. JSEE issued its first publication in April this year, entitled "Engineering Education," and held its first annual meeting in Tokyo at the Engineer's Club July 9–10.

A Study of Teaching Methods in Engineering*

By W. R. LEPAGE, *Professor*
and
R. P. LETT, *Assistant Professor*
Electrical Engineering Department, Syracuse University

For many years it has been common practice in college teaching of so-called lecture and recitation courses to assume that if the teacher was familiar with the subject matter it was only necessary for him to "present" the material to the class, after which the student would obligingly learn the subject and everyone would be happy. Unfortunately, it seems to work this way for only a very small percentage of the students of an average class. Realization of this fact on the part of some members of the E.E. staff at Syracuse University has led to a series of experimentally conducted courses. Of course, no panacea could be expected, but a series of procedures have been tried which finally lead up to a technique which, it is believed, shows promise of being superior to the traditional methods.

To begin with, it is important to state what we believe should be the objectives in a teaching relationship. Accordingly, the following objectives were considered important for the experiments under study. The student should:

1. Acquire a knowledge of the facts, terminology, conventions, and methodology of the subject matter of the course.
2. Acquire a comprehension of the fundamental principles of the course and an ability to apply, interpret and extrapolate these principles.
3. Develop an ability to analyze and synthesize situations involving these principles.
4. Develop self reliance so that further study in this field and in related fields, by the student alone, will be possible.
5. Develop an ability to evaluate and exercise reliable judgments in the course area and related fields as well as some grasp of self-evaluation.

In reviewing the possibilities for varying teaching techniques it is fruitful to give thought to certain psychological effects which may be overlooked in the usual classroom situation. It is felt that the following factors should be given more attention in teaching methods than is usually the case.

1. The student should be at ease in the classroom situation.
2. The student should be made to feel that the teacher is his friend and helper, and therefore his employee, rather than in competition with him.
3. Emphasis on grades should be minimized, so that the student will feel that his purpose is to gain insight and understanding rather than a label of a certain degree of "accomplishment" in the records office.
4. It should be realized that a student really learns only those things he wants to know, and is not particularly influenced by what the teacher thinks he should be interested in. In psychological parlance this is to say that the teacher can communicate with the student only if there is

* Presented at the annual Meeting of ASEE, Educational Methods Division, Univ. of Florida, June, 1953.

considerable overlap of the "phenomenological" fields of the two individuals.†

5. Closely allied with point 4, the classroom should be a place of real learning, rather than a place of "entertainment."

6. The student should *not* look to the teacher as an absolute authority.

In view of these considerations, with the help of members of the Education Department of Syracuse University ‡ an experimental teaching program was set up in a beginning course in A–C Circuits. This experiment is reported upon elsewhere,§ and so the report given herewith continues after the termination of experiment 1. Suffice it to say that the first experiment utilized the so-called non-directive approach, leaving the student wide leeway to learn by himself.

Some Difficulties

Some difficulties were experienced with that method. In particular, there was no adequate way to arrive at a grade at the end of the term, and with the pressure of other courses some students tended to neglect the non-directively taught course. Therefore, although the non-directive method did show good results in some respects, in view of the need for grades, and the competition with other courses, other less radical techniques were tried. The present paper consists of an outline of three successive experiments, following experiment 1, with results such as they are known to us. Whereas experiment 1 was conducted with a control group, experiment 2, 3, and 4 had no controls, and so evaluation of results is less objective than would be desired.

Experiment 2 (Student-centered A)

This is called a student-centered method rather than non-directive, because attention was directed at helping the student to feel that the class belonged to him, while the teacher actually assumed quite a bit of direction over the work. The following quotation from the instructions given to the students indicates the essence of this experimental method.

All of the material needed for an understanding of the subject is the text. Therefore, there is no need to have the instructor lecture on the subject matter that can be acquired by reading. The student is largely on his own to get his first contact with the material, from the text. The class period will serve as a discussion time, and as a period for working problems. Most of the discussion may arise out of the exercise problems. There will be no essential difference in the manner of conducting the "problem session" and the "recitation session." They are both to be considered as combined problem-working and discussion meetings.

Discussion among small groups of students is to be encouraged. Different students will progress at different rates, and so there may be various discussions going on simultaneously. It is hoped that a complete atmosphere of informality can be attained.

Teacher is Consultant

The purpose of the exercise problems is to gain an understanding of the principles they illustrate. They are not to be worked merely for the purpose of having them checked off in the instructor's record book. For this reason, problems will not be collected and graded. The teacher's only role is as a consultant.

Quizzes are to be regarded as measuring scales, to determine your attainment, rather than as final irrevocable evaluations. If the results of a quiz show that you do not have a certain minimum of understanding, you will be given another chance, without penalty. That is, the quiz grade will not be recorded, unless it is above a certain minimum. Although the instructor's role is that of helper and consultant, he retains the role of judge, to the extent of deciding whether the attainment of each student meets the minimum standard. If a student does not meet the minimum requirements, as judged by the instructor, another quiz can be given, after the instructor is satisfied that more

† Snygg and Combs, "Individual Behavior" Harper Bros. 1949.

‡ Particularly Dr. K. N. Peterson.

§ To be arranged.

studying has been done after the unsuccessful attempt. He may require proof of additional work having been done, if he deems it necessary. Furthermore, he reserves the right to refuse to give additional quizzes, if he feels that the student is not making an effort. If this is done, it is not in a punitive sense, but to protect himself against the contingency that a student may attempt to take quizzes repeatedly, without studying, in the hope that eventually he will "hit" one he can do.

It is suggested that the class members make out the quizzes, using the problem book, and the question sheets, as a guide. The appropriate number of quizzes required to cover the work can be decided by the class. Two or three students can make out each quiz, with the aid of the instructor. This job can be passed around the class as the term progresses. In any event, the members of the class should feel that in reality it is the class as a group which is testing the individual members of the class, and employing the instructor to help them in the process.

It will be noted that the method of quizzing is one of the unique features of this experiment. It was hoped that the method would develop a sane attitude toward grades, while at the same time being more effective than usual methods of weeding out students who do inadequate work. With the usual method of quizzing, a student who fails to pass a quiz is normally allowed to continue, always with hope in his heart that somehow he will do better the next time; while the chances of his doing better quickly fade as he fails quiz after quiz. With the procedure of experiment 2 an inadequate student merely fails to complete the course. That is, he may spend a whole term on only half of the work; but the important thing to note is that he is not allowed to go unprepared into new work, because no quiz may be taken if the previous one has not been passed with a certain minimum standard.

The method did accomplish the above objective to some extent. In fact, one of the desirable features was that it caused a few students to drop the course early in the term, when they saw that they had no hope of success. The number of quizzes became too great, however, to continue student authorship.

Make-up Quizzes

Probably the greatest drawback to the method was the need for a large number of make-up quizzes, and that there was no pacing of the course by the instructor. In many instances instructors had to make up individual quizzes for single students, because a quiz was given "on request" whenever a student claimed to be ready for it. The result was that some students did the second half of the course in the last two weeks of the term. Also the students felt that class time was not used efficiently, as shown on an unsigned student questionnaire. (See Chart 1.)

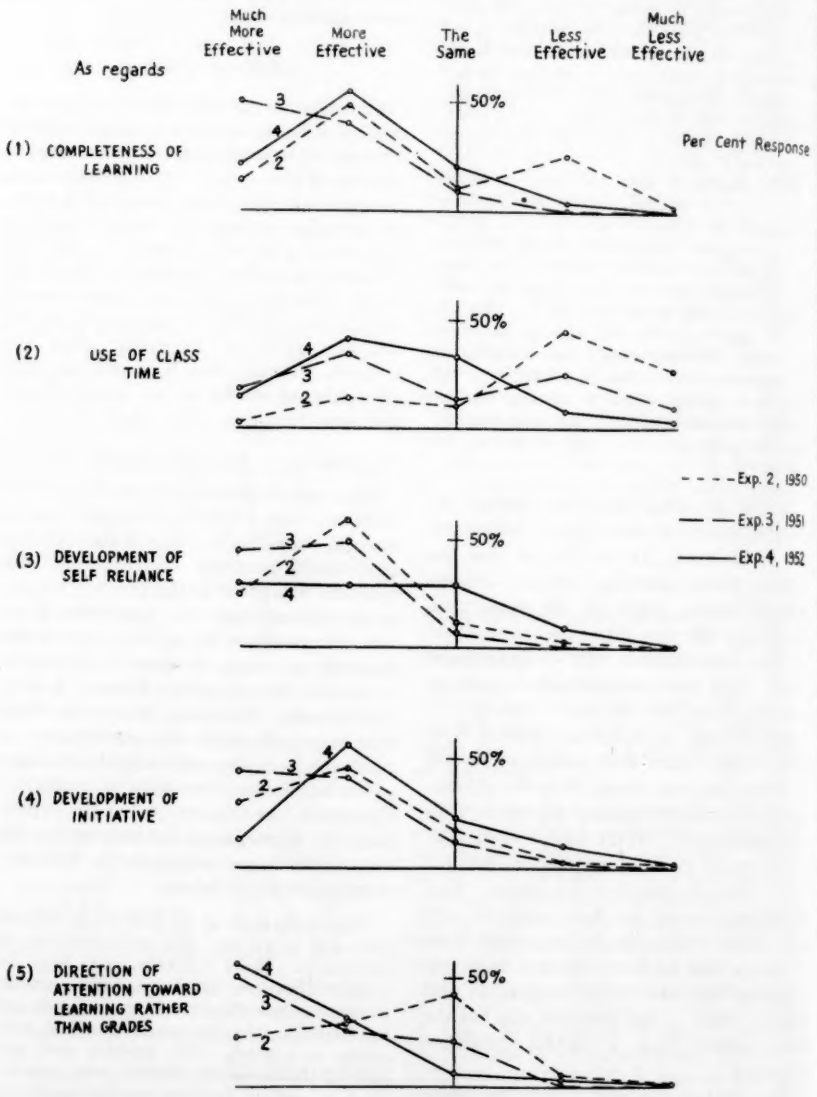
Experiment 3 (Student-centered B)

The next method tried was an attempt to remove one difficulty of experiment 2; namely, the difficulty that the class did not pace itself properly. Accordingly, this function was given to the faculty, but not to the student's teacher. The pacing function was not given to the teacher in order to avoid as much as possible returning to a state of competition between student and teacher. Class room procedure otherwise remained about the same as in experiment 2, as was explained to the class at the beginning of the term in an instruction much like the one quoted for experiment 2. Excerpts of the instructions for experiment 3, pertaining to the quiz procedure, are given below.

Your instructor, as an individual, will not give you a grade. His only function, in relation to you as a person, is to help you learn. However, since we must produce grades for the office record, your grade will be determined by the course teaching *staff*, acting as a group. The teaching staff consists of the course coordinator, who does not teach a section, and the section instructor. To see how the quiz and grading system will work, read the following description.

CHART 1

Compared with *other* courses, this course was:



The term will be divided into quarters. At the end of each of the first three quarters a quiz will be given, and then there will be an examination at the end of the fourth quarter. These quizzes, and the examination, will be called the GRADED QUIZZES. They will be made up by the course coordinator and graded by the staff, cooperatively. Your instructor will not participate in making up the graded quizzes, but he will have veto power over any question he may consider unreasonable. Your grade in the course will be determined from the results of the four graded quizzes, *with the one modification explained below.*

Your instructor will make sure you learn a minimum acceptable amount before allowing you to take one of the graded quizzes. In order to do this he will make up and give his own quizzes, which will be called PRELIMINARY QUIZZES. These quizzes will test you for minimum standards. There will be several preliminary quizzes between two successive graded quizzes, and the preliminary quizzes will come in sequence. You must pass each of them in its proper sequence in order to be admitted to the next graded quiz. The preliminary quizzes will be graded as either "satisfactory" or "unsatisfactory." A failure in a preliminary quiz may be made up without penalty. These quizzes are merely measuring gauges against which you test your progress, and a failure indicates there hasn't been enough progress. More study is then needed. In some instances a preliminary quiz may be an informal oral quiz, or it may be waived at the discretion of the instructor, if he feels that observation of class work has provided adequate proof of progress. There will be no waiving of these quizzes for the entire class, only for individual students.

Typical Example

To consider a typical example, suppose the first quarter of the work covers chapters 1, 2, and 3 of the book. Your instructor may elect to give a preliminary quiz on each chapter. You must obtain a grade of "satisfactory" for the quiz on chapter 1 before you may take a quiz on chapter 2, and so on. Finally, you must have passed preliminary quizzes on all three chapters before you may take the graded quiz on the first block of work.

You will note that by the time you have earned the right to take the graded quiz you have met minimum standards by passing the preliminary quizzes. It is therefore reasonable to say that you have attained a grade of C in that part of the work covered by those preliminary quizzes. Therefore, if you are satisfied with a grade of C you need not take the graded quiz at all, or you may elect to take it in order to demonstrate your attainment beyond the C level. In the event that you obtain a grade of less than C in the graded quiz, that grade will be disregarded and you will be given a C on the basis of your preliminary quizzes.

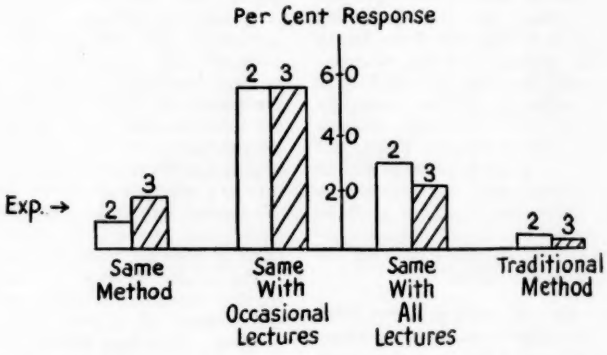
The graded quizzes will be given on a regular schedule, in order to ensure the maintenance of a reasonable schedule or progress. You may therefore wonder what will be done if you should not complete the necessary series of preliminary quizzes by the time of the graded quiz. You will be given every opportunity to meet this deadline; that is, your instructor will cooperate in giving you the necessary preliminary quizzes repeatedly, as long as he is convinced that you are working. However, suppose you still don't meet the deadline and are not admitted to the graded quiz. Of course, if you have a legitimate excuse, you will be given a make up. Lacking an excuse, you will still be given a make up, when you are ready, but the grade attained will be multiplied by the factor 0.7. Furthermore, you will not be entitled to the C grade for having completed the preliminary quizzes, because they were not completed on time.

A failure to meet a graded quiz deadline, without excuse, should be regarded as a serious situation. Should this happen, every effort should be made to close up the gap without delay. However, no time limit is placed on the make up, except that preliminary quizzes in the next quarter will not be given to a student who has not completed the previous quarter. Thus the deficiency of not meeting a deadline of a graded quiz can rapidly become cumulative and lead to failure in the course. Thus, failure in a course taught on this plan will be by not completing the work, rather than by failing graded examinations. We hope there will be no failures.

Student Response Favorable

Student response to this method of teaching was quite favorable, as is brought

CHART 2



out in the subsequent tabulation of the results of student questionnaires. (See Chart 1.) The experiment was tried in two different courses; in an electronic course for EE majors, and the other the first semester of an electrical "service course" for non-electrical students. It appears that the greatest success was scored in the latter course, which was significant because students in past years had shown much apathy toward this course. A fine degree of student cooperation was attained, and there is reason to believe the students learned more than in any of the previous courses taught by other methods. However, the teaching staff was seriously overworked, both in giving help in out-of-class hours, and especially in making out preliminary quizzes and make-ups. In this connection, it is interesting to note a very pronounced tendency for the students to skip the first preliminary quiz, in order to see what it was like, the better to prepare for the make-up. This increased the quiz-making burden beyond what had been anticipated. The making of quizzes was particularly difficult because of the desire to include some new material in each successive make up quiz.

Students reaction to this method, as obtained from the same questionnaire, is also indicated in Chart 1. During the term, many favorable verbal reactions came in, and several favorable comments were appended to the questionnaires. In addition, the students were asked to choose between four methods of conducting courses, varying from this experiment to the traditional system. The results are shown in Chart 2, which shows the students overwhelmingly rejected the traditional approach.

Experiment 4

The excessive demands on instructor time of experiment 3 may have been due to student unfamiliarity with these methods and long established student dependence on "spoon-feeding." After a semester, it was felt that the method could be tightened up and the following changes were instituted as indicated by the following quotation from the instructions given to the students.

a) Only one "Preliminary" quiz and one make-up quiz on each section of the work will be scheduled, and no student will be permitted to take the make up unless he has first taken the preliminary. (The usual rules on absence from quizzes will be followed.)

b) A student may elect to skip one or more preliminary quizzes, but in this case he is now required to take the "graded" quiz and the grade he gets on it. If one or more preliminary quizzes are skipped the "C" guarantee lapses.

Two other departures from previous procedure were also instituted. Due to the

wide scope of the survey material a partial return to the lecture technique occurred. The instructor lectured.

a) When the text in his opinion did not meet the course requirements
b) When new concepts caused difficulties
c) When members of the class requested information on a certain topic.

The amount of lecturing varied among the four sections, but probably averaged one half to two thirds of the class periods. The remaining periods were devoted to problem work and discussion groups. The other innovation was to permit a student to write a report on some phase of the application of Electrical Engineering in his own field. The grade on this report was substituted for the lowest of the student's grades on the graded quizzes. This had been tried the previous year and the high quality of most of the reports and the increased interest in the survey course had indicated that this project was educationally valuable.

Reactions Favorable

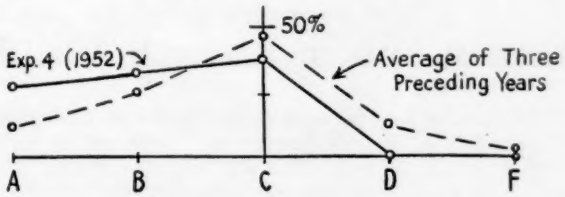
Students reacted favorably to this method. Not more than two or three students (out of the four sections of 20 each) were content to "coast" for a C grade. The grades given were higher on the average than those of previous years as shown in Chart 3, and the class average on the rather comprehensive final exam was not significantly different although slightly higher than the average of the three previous years on an entirely comparable exam.

Two student questionnaires were given at the end of experiment 4. One of these was essentially the same questionnaire used with experiments 2 and 3. As indicated by the summary in Chart 1, the students felt that experiment 4 was preferable to the previous experiments, and much more preferable to other methods of teaching as regards completeness of learning, use of class time, development of initiative and interest, and the direction of attention toward learning rather than grades. The release of exam tension was mentioned as an important factor.

A second questionnaire, which was the student opinionnaire, developed by the Evaluation Service Center of Syracuse University, was given at the end of experiment 4. This opinionnaire has been refined over the past seven years and sufficient norms have been developed so that a good indication of student reaction to

CHART 3

Grade Distribution of EE 46 in Per Cent



Final Exam Average EE 46

1952 (Experiment 4) 65.6%

Average of Three Preceding Years . . . 62.2%

teaching procedures can be obtained. This opinionnaire is not designed to judge the effectiveness of teachers and teaching but has been used successfully to help instructors, who are the only ones to see the results. This opinionnaire covers five general areas as follows:

1. Instructional materials and objectives
2. Instructional procedure
3. Tests, exams and quizzes
4. Value of the course to the student
5. Instructor-student relations

The group under consideration scored very significantly higher in all areas as compared with the norms set up over several years on several thousand students, but the most outstanding difference was in the last area, instructor-student relations. In this area the student responses were unbelievably high, part of which may be due to the enthusiasm and cooperation of the young instructors who were teaching this course. Incidentally, extensive checks over several years have shown neglible correlation between the answers on this opinionnaire and the students' grades or expected grades.

Recapitulation

It seems obvious to the authors that after much trial and error there has been evolved a more successful method of teaching. While by no means the final word on the subject, the objectives stated at the beginning of this paper have been attained to a considerable extent. There has been enough follow-up of students in later courses to justify a good deal of optimism. Chart 1 is particularly interesting, especially groups 1, 2, and 5, which show not only that the objectives were being obtained but that the students were able to detect the improvement as the methods were refined.

Of course there were many other variables. One of the most important of these was the fact that the student was exposed to this one "student-centered" course at the same time he was taking perhaps four others which were given in a traditional manner. Under the pressure of an engineering curriculum it is easy for the student to slight courses which do not require daily work turned in, and these methods might show to better advantage if they were more universally employed. Another factor which may have been beneficial, was the youth and willingness of the instructional staff, who, having no fixed pedagogical habits, adapted themselves enthusiastically to these experiments. In conclusion the authors can only say they feel that if these methods were instituted earlier in the students' educational career that they might well constitute one answer to the increased amount of material now required in engineering curricula.

Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.

Methods of Testing Student Proficiency in the Basic Use of Surveying Instruments

By COL. M. S. DICKSON

Associate Professor, Department of Military Topography and Graphics, United States Military Academy, West Point, N. Y.

Surveying has been part of the West Point curriculum from its inception in 1802. In his diary, Jonathan Williams, the first Superintendent of the Academy, describes his leading the cadets in and around West Point for the purpose of making surveys. In addition to familiarizing the cadets with surveying instruments and practices, these surveys were for many years used as the official community land records.

For the first quarter century of West Point's history, surveying and mapping were limited to establishing boundary lines for land ownership. In the 1820's, our young energetic Nation, eager to explore and exploit the rich lands to the West, realized a serious need for engineers, especially surveyors. Therefore, West Point's curriculum was pointed towards engineering in an endeavor to fill this need. Early American history reveals many West Pointers assigned to the Topographic Engineers, U. S. Army, leading the way in exploring, surveying, and mapping the Great Northwest Territory.

Cadets at West Point are required to take, in general, identical academic courses. The Academy curriculum is two-thirds technical-scientific and one-third humanities. There are no electives within the technical-scientific curriculum. Each cadet is required to complete each engineering subject. The curriculum is designed to provide a broad general engineering background to give each graduate a solid foundation for a lifetime of growth in the military service regardless of branch or assignment.

Since all cadets must take surveying, an average class of approximately 600 reports to the Department of Military Topography and Graphics for surveying instruction each September. Surveying is given during the Fall to take advantage of the good weather for outdoor exercises. Subject matter is similar to that in elementary surveying courses given by many engineering schools to general engineering students. Instruction throughout emphasizes the many military applications of Surveying. It is useless for me to enumerate to you gentlemen the many applications. The course consists of approximately 52 two-hour periods of instruction. Since the course is considered a subcourse of Military Topography, the mapping applications of surveying are stressed.

Early lessons of the course comprise a classroom study of theoretical surveying. At present we are using the text "Elementary Surveying" by Professor Warren C. Taylor, Union College. Upon completion of the theoretical work, cadets are given field instruction in the use of the basic instruments—level, transit, plane table, and alidade. This instruction is not designed to produce surveyors, but rather to teach the principles of operation and the capabilities of each instrument. Instruction resembles field work given by most universities, i.e., dividing the class into field parties to solve practical problems with each instrument as time permits. In each class of 600 cadets, we always find a great range in surveying aptitude. Some cadets have the facility and the desire to excel in the course, while others strive only for a

passing grade. I imagine many of you here have experienced similar problems. At West Point, those who excel are called "Engineers," while the lesser lights are dubbed "Goats."

Deplored Situation

For years instructors have deplored the following situation. As soon as a party starts work on an outdoor problem, the most apt member of the party operates the instrument, while the goat holds the rod. Instructors continually stress that duties should be rotated, giving each member equal experience. The rotation method usually operates satisfactorily, until a graded problem is assigned. Since all members of the party must necessarily receive the same grade, you can well imagine the anguish of the Engineer (Phi Beta Kappa prospect) standing across the field, holding a rod, patiently watching his grade develop or disintegrate through the efforts of his Goat party-mate attempting to read, record and compute. To eliminate this objectionable situation, the Department ruled that field exercises would be ungraded instruction, taking full advantage of the coach and pupil method to increase facility with an understanding of the instruments throughout the class. At the completion of field instruction, cadets are graded from results of examinations requiring every cadet to individually operate each basic instrument. While discussing the course with a few of the members of this Society, several expressed interest in how we conducted individual performance tests on each of the surveying instruments for six hundred cadets within our limited instruction time. The remainder of this paper is a description of our individual instrument performance tests.

Due to the limited time available for the performance exam, requirements cover only the basic essentials of instrument operation. The three graded exercises require the cadets to:

a. Transit—Properly set up the instrument over a designated point, measure several horizontal and vertical angles, compute horizontal and vertical distance by use of stadia, and properly record the observations.

b. Plane Table and Alidade—Properly set up and orient the table, plot accurately the horizontal location of several points, and compute and record the elevation of the plotted points.

c. Level—Properly set up the level, carry a line of levels through a three-station set-up, and properly record the observations.

The performance tests are conducted in the Military Academy Field House, because the schedule requires that they be given in December, near the completion of the Surveying course, when outdoor weather is extremely uncertain. Since the cadet's grade and relative order of merit for the Surveying course is dependent upon the results of the performance examinations, it is obvious that tests for all cadets must be conducted under equal working conditions. Spotlights are used to adequately light rods not properly readable under Field House lighting. Tests on all three instruments are run simultaneously to obtain the most efficient use of both instruction time and available instruments. All rods used during the exercises are either fastened to the Field House walls or are set up in holders to eliminate the need for rodmen. Elimination of rodmen allows each cadet to use one hundred per cent of his available time in reading and operating the instruments and recording results. In each case rods are adjustable to allow frequent changes in results.

Performance Tests

Performance tests are conducted as follows:

a. Transit—Two circles approximately 150′ in diameter are laid out in one end of the Field House with instrument stations as required at about 10′ intervals placed on the circumference of the circles. Three rods, labeled A, B, and C, are placed on each circle directly opposite

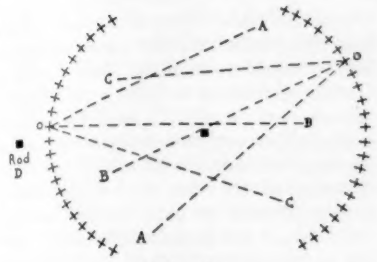


FIG. 1.

each group of instrument stations. The two circles and two sets of rods—A, B, and C—are necessary to accommodate the large number of cadets taking the exam simultaneously. A four-faced stadia rod is placed near the center of the overlap area of the two circles. Two stadia rods, labeled E and D, are fastened to the walls of the Field House at elevations higher than the instrument stations. The transit exercise layout is shown in Figure 1. At the start of the problem, cadets are given the elevation of the base of the four-sided stadia rod. They are then required to properly set up the transit over their assigned station, then to measure accurately the values of the angles AOB, BOC, and COA, and finally to compute the elevations of the rods D and E by stadia methods.

Although not obvious to the cadets, the use of the circular layout results in all stations on each circle having identical correct solutions. This enables one instructor to control, correct, and grade promptly the large number of cadets under his jurisdiction. Upon completion of a group examination, instructors move

FIG. 2.

the rods and vary the solutions for the succeeding group.

b. Plane Table—Predetermined station points are referenced in and marked on the central portion of the floor of the Field House. The plane table layout is shown in Figure 2. A plotting sheet with all table stations located is given to each cadet. In addition, two orientation points are located on the issued plane table sheet. Orientation points are two rods, one at each end of the Field House, plainly labeled and visible from all stations. Four rods not plotted on the given sheet are located on the walls of the Field House at varying elevations (shown on Figure 2, labeled Rod A, B, C, and D). Each cadet is then assigned a station indicated on his plane table sheet and is given the elevation of the base of Rod A. He is then required to properly set up the plane table, orient the board, plot on the sheet the horizontal locations to scale of points A, B, C, and D, and to obtain the elevations of Rods B, C and D with respect to the given elevation of Rod A. Supervision, control and grading of this problem can be easily accomplished by the instructor for the large number of cadets under his jurisdiction by using a check overlay.

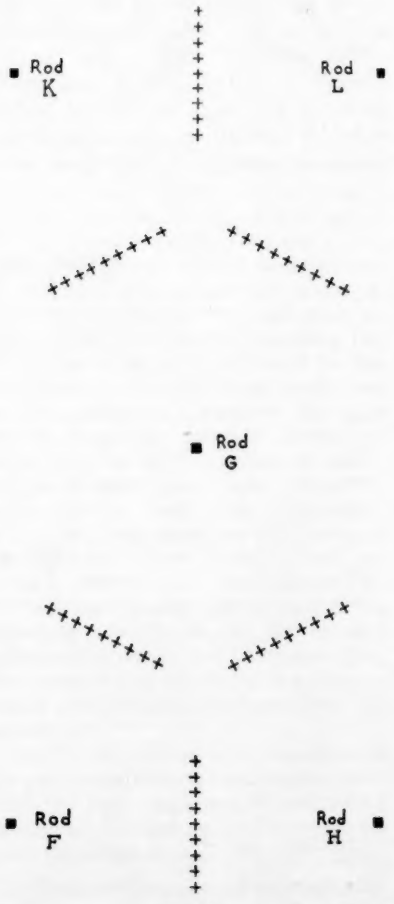


FIG. 3.

c. Level—Two level circuits of three stations each are laid out at the opposite end of the Field House from the transit layout, as shown in Figure 3. Two circuits—one FGH, the second GKL—are necessary to accommodate the large number of cadets taking the exercise simultaneously. Levels are placed on the lines indicated by the x's in the figure. Originally cadets carried an assigned instrument from set-up to set-up between the rods while making the circuit. This past year, to eliminate confusion, instruments were left in position, with cadets using any available instrument at each station. Instructors insured that each instrument was thrown out of level after each use. Rod G is considered to be placed on a bench mark of known elevation. Cadets are given the elevation of Rod G, are then required to run the circuit of three rods, computing and properly recording the notes for elevations of Rods K and L, then closing back on the bench mark, Rod G. To complete the requirement, they are required to adjust the circuit for any error of closure.

Each performance test—transit, plane table, or level—is scheduled for one hour's completion. Each cadet is scheduled to take each test twice at the completion of the field work. A repeat on each problem is given to encourage the cadet to

discuss his errors of the first performance with his classmates in an effort to learn and improve his instrument techniques for the final attempt. In many cases the more apt cadets give perfect performance on the first trial. In this case they are given a bonus score of 100% for both first and second tests and are not required to repeat a perfect performance.

The Field House set-up is geared for mass production, since there is an average of 600 students taking the course each fall. In order to quickly execute the exercises, the class is divided into quarters, with about 150 students participating simultaneously. To accomplish this, each individual type instrument set-up is designed to handle one-third of the 150, or 50 students per hour.

Conclusion

We have found the tests extremely beneficial, particularly in forcing our cadets to handle the instruments themselves in lieu of leaning on a more apt member of a party group. We believe it definitely establishes an indication as to which student understands the basic operations of the instruments, combined with the application of the theoretical classroom work.

Summer Schools

This year the Society will sponsor six Summer Schools, the largest number ever sponsored in any one year. These include:

Machine Design sponsored by the Mechanical Engineering Division, E. E. Ambrosius, *Chairman,* Pennsylvania State University.

Humanistic-Social Studies, S. P. Olmsted, *Chairman,* Rensselaer Polytechnic Institute.

Graduate Study by Engineering Mechanics Division, H. R. Lissner, *Chairman,* Wayne University.

Engineering Economics sponsored by the Engineering Economy Committee, A. Lesser, Jr., *Chairman,* Stevens Institute of Technology.

Electrical Engineering, L. V. Bewley, *Chairman,* Lehigh University.

Summer School sponsored jointly by the General Electric Company and the Educational Methods Division, R. L. Sweigert, *Chairman,* Georgia Institute of Technology.

For information concerning these Summer Schools, please write to chairmen at the above addresses.

In addition to these Summer Schools, there will be a one-day conference sponsored jointly by the Instrument Society of America and ASEE on Saturday preceding the Conference on the general subject of the teaching of instrumentation.

Education Beneath the Surface

By R. B. DAVIS

Assistant Professor of Mathematics, University of New Hampshire

I should like to make three points of quite different sorts:

1. There is frequently a great need in universities to integrate separate departments and to develop "border-line" or "inter-disciplinary" areas of knowledge. One sees a great contrast between different universities in this respect.

In some, a student learns differentiation of x^n in calculus on Monday, say, and uses it in physics later that same week. The physics, mathematics, and engineering textbooks are perhaps even written explicitly for use together, and notations and order of topics are correlated.

In other universities, however, there are gaps between different courses or departments which most students are never able to bridge. There may be no course in mathematics which meets the needs of an electrical engineer. A student may learn calculus, then not use it in physics; or, if it is used at all, either the notations may be so different that the student must use one and forget the other, without being able to combine them effectively, or else perhaps there may be a gap of a year or so between courses, so that the student forgets differentiation before he has any opportunity to use it in physics and engineering. Possibly the student learns more mathematics than is used in his other courses, even where it would fit in quite naturally. Teachers of some courses are likely to be unaware of the definitions, methods, and notations for closely related material presented in other courses. The physics, mathematics, and engineering departments may all have different notions of what a vector is, for example.

The effect on the student is to make studying vastly more difficult for him, to give him the idea that much of what he has been taught is useless "in practice," and to prevent him from achieving facility in the use of mathematics in his engineering work.

Learning Under Pressure

2. Students are not able to learn deeply or profoundly under pressure. "I'd like to understand this," a student says, "but if I try to understand it fully it will take too long. In order to be ready for next week's quiz, I shall merely learn the technique by rote."

Some will say that putting pressure on the student is necessary, otherwise he will not learn. Others may say that we must face rote teaching, in certain cases at least, as one of the unpleasant necessities of life. I believe, however, that teaching and learning by rote have extremely little place in a proper university education, engineering or otherwise. I think that a tremendous amount of progress can be made in teaching the student to *understand*; we do not need to rely on rote in our teaching so much as some instructors imagine. Just how we can escape rote, just how we can replace it by something better, is perhaps one of the most exciting areas of scientific investigation at present, involving the work of many teachers, psychologists, and other specialists, such as Nathaniel Cantor, Carl Rogers, Lawrence Kubie, and William Alanson White. This is essentially a new area, but its promise is already great. One thing that is clear is that we must *remove* some of the pres-

sure from students if we want them to learn things profoundly. Over-frequent examinations or over-bearing professors are effective obstacles on the road to genuine understanding.

Learning Cannot Be Imposed

3. Learning must be done by the student himself. A faculty cannot impose learning upon students, cannot imprint it there with a rubber stamp procedure. Teaching must build upon the student's own opinions and his own experience; these can and usually must be modified greatly as a result of the educational experience. They cannot, however, be modified by a faculty that lectures to the student. The student must learn for himself.

This requires three things of a faculty member: (1) he must respect the student, and respect the student's experiences and opinions; (2) he must know how to lead the student to change these opinions by new experience in college and afterwards; (3) he must not take the initiative away from the student.

These are difficult matters for the faculty member; the student frequently invites the professor to take complete charge, to reduce everything to a matter of rote. On such an occasion, the professor must steer between two shoals, saying to himself: "If I do take complete charge, if I use my judgment and do not require the student to use his, there will be no genuine learning for the student. He will watch, imitate, and later forget. I must make him decide this question for himself. But, on the other hand, if I do *not* take the initiative, the student may feel that I have let him down."

The most satisfactory answer seems to be for the professor to use the warmth of his personality to provide reassurance and support, but to insist that most of the initiative come from the student. Good teachers often do this instinctively. They don't tell the student the answer, nor do they tell him how to get it, but instead they lead him to discover the method for himself.

This can be taken into the organization of the course, as well as into the detailed solution of problems. It is usually desirable to do so, since the over-all atmosphere in a course is far more important than any of the details. An over-all atmosphere of student initiative, as opposed to dependence upon the instructor, can often be furthered by an arrangement whereby students determine the dates of examinations, select the homework assignments, and set the pace for the course. They then know *why* they are studying a particular topic, they know what they expect to get out of a certain problem. Moreover, undesirable dependence upon the instructor, or resentment at being continually manipulated, is minimized by an atmosphere where the student makes many of the decisions concerning the organization of the course.

Atmosphere Is Important

In this, again, the atmosphere is the important thing. It's not what you do, it's the way that you do it. If the professor is alive with his subject, if he is warm and sympathetic to students, he need not fear that the classwork will lag. Virtually every student responds to a friendly, creative atmosphere, and approaches the work with enthusiasm and ambition.

In college we frequently tell the student what to do, we tell him how to do it, and when he has done it, we tell him how well he has succeeded. I believe this is a mistake. More of this should be left up to the student himself. After all, no one becomes a good, productive scientist, engineer, teacher, or citizen because someone else forces him to. Only his own initiative and sense of values can possibly do the trick.

An Analysis of Mineral Industry Engineering Curricula *

By J. D. FORRESTER

Professor and Chairman, Department of Mining Engineering, Missouri School of Mines and Metallurgy

This analysis has been prepared by the writer in his capacity as chairman of a committee which was appointed in October 1952 by Dean James R. Cudworth, Vice Chairman, Southeast Section, American Society for Engineering Education. The objectives of the committee have been to study and report concerning the engineering curricula to be established in universities and colleges for pursuit of training for professional work in the minerals industry. Other committee members are Professors A. V. Corlett, C. S. Crouse, R. T. Gallagher, N. H. Manderfield, H. H. Power and Dean J. P. Spielman.

The committee work has developed as a result of a resolution formulated at the Dartmouth College meeting of the Mineral Division, ASEE in June 1952. The action was: "Resolved that the officers of the Mineral Division study the desirability of starting studies to determine the minimum curriculum requirements for accrediting purposes for various groups within the Division." The interpretation subsequently placed upon the above directive by the officers of the division is one wherein the committee specifically has been charged to accomplish the following:

A. Establish the branches within the division which should be classed as "engineering."

B. Establish minimum curriculum requirements for these branches.

* Presented at the Annual Meeting of ASEE, Univ. of Florida, June, 1953.

A. *Branches of Work of Engineering Character in Mineral Industry Education.*

It is necessary and desirable that "engineering" be defined before an analysis is undertaken to fix what work is of such scope in the Mineral Industry. There are many definitions of the term—some of broad nature and some more restrictive—but, on thorough study, it is apparent that all incorporate the following elements:

1. Engineering is a profession in which men apply the physical sciences creatively to meet the needs and wishes of their society.

2. Engineering is a profession in which science is practiced for economic gain.

As stated by Dean S. C. Hollister, "An engineer is characterized by his ability to apply creatively scientific principles to synthesize, develop or design structures, machines, apparatus, or manufacturing processes, or works using them singly or in combination; or to construct or operate the same with full knowledge of their design, and of the limitations of behavior imposed by such design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation, and safety to life and property."

On the basis of the above and with specific reference to the Mineral Industry, it is found that areas of professional engineering enterprise are logically divisible

into three major spheres of endeavor, namely:

1. The exploration, discovery, and prospecting of new mineral deposits of the earth's crust.
2. The production and development of known mineral masses occurring in and on the earth's crust.
3. The beneficiation and processing of mineral substances that have been produced from the earth's crust.

Any engineering activity related to the procurement or control of mineral materials (including oil, coal, water or natural gas) is a function within the general scope of one of these major spheres of work. Therefore, this committee proposes that the Mineral Division of the American Society for Engineering Education recognize and establish the existence of three basic major mineral engineering branches, namely:

I. Mineral Exploration Engineering.
II. Mineral Production Engineering.
III. Mineral Process Engineering.

Although the committee is fully cognizant of the fact that mineral industry nomenclature is deeply entrenched by usage, etc., and hence, it may be somewhat difficult to accomplish the immediate, widespread acceptance of the proposed new names, it (the committee) is equally of the opinion that much of our so-called designatory terminology simply is inherited from the past and in reality often is poorly descriptive of modern viewpoints and practices. If the above branches are accepted as the primary or basic divisions of mineral engineering, they will prove to be restrictively unique but, at the same time, of such compass as to be logically inclusive of special professional fields or interests. Findings by others who have studied and written about mineral engineering curricula, when correlated generally with those of this committee, lead to the recommendation that mineral engineering branches and their respective particular curricula should be adopted, as follows:

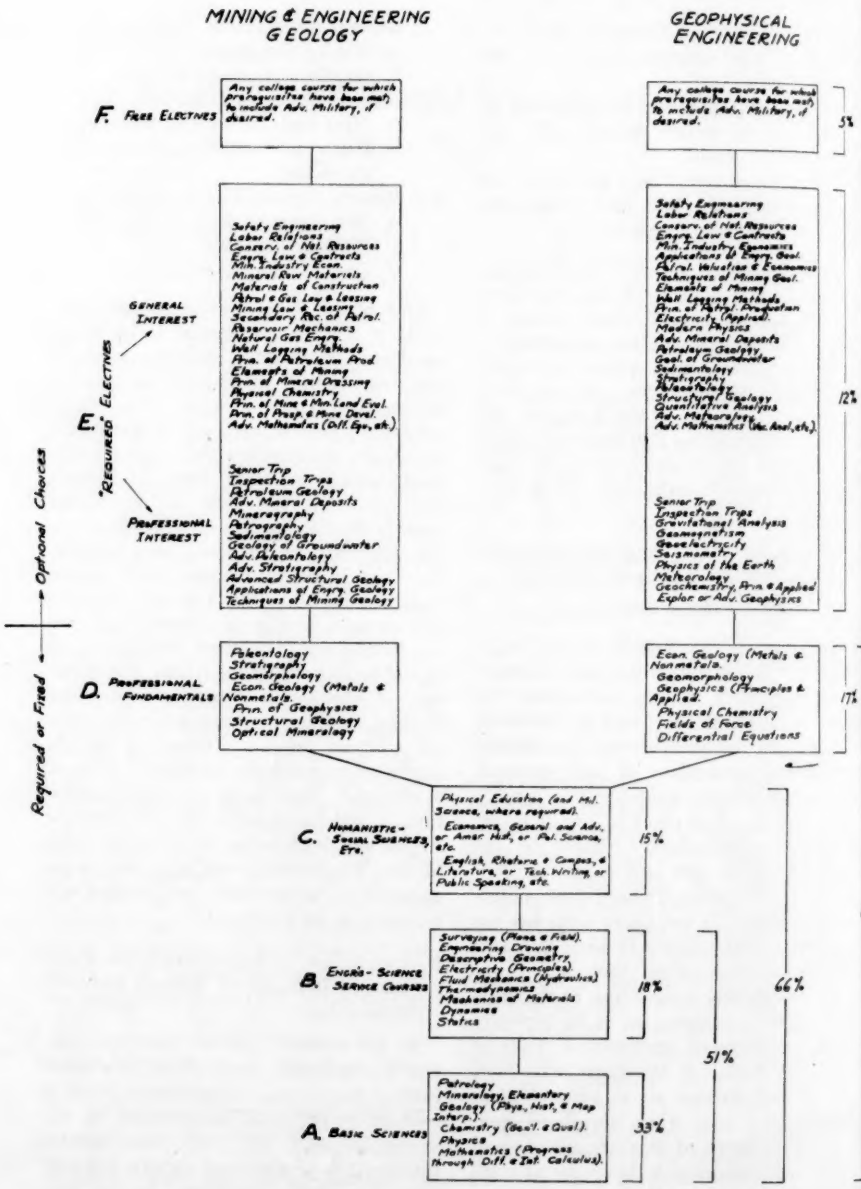
I. Mineral Exploration Engineering.
  A. Mining and Engineering Geology.
  B. Geophysical Engineering.
II. Mineral Production Engineering.
  A. Mine and Quarry Engineering.
  B. Petroleum and Natural Gas Engineering.
III. Mineral Process Engineering.
  A. Metallurgical Engineering.
  B. Mineral Dressing.
  C. Ceramic Engineering.

Each of the above mineral industry curricula is of such character as to be recognized as of engineering scope because each will stand critical analysis on the basis of the accepted definition of the term "engineering." That is, each given curriculum essentially incorporates the necessary elements which comprise Dean Hollister's statement. At this time, the committee believes that above list of mineral industry curricula is sufficient and proper. However, it can be enlarged or expanded in any particular branch should progressive changes develop in mineral engineering technology to warrant extension. It should be realized by the reader that adoption of the above proposals concerning Mineral Engineering branches and curricula will not require a school to modify markedly its presently established "plan of operation." That is, in any given institution, it will be possible still to designate Petroleum Engineering as a specific field; Mining Engineering will maintain as an engineering curriculum; Ore Dressing will continue as an entity, etc.

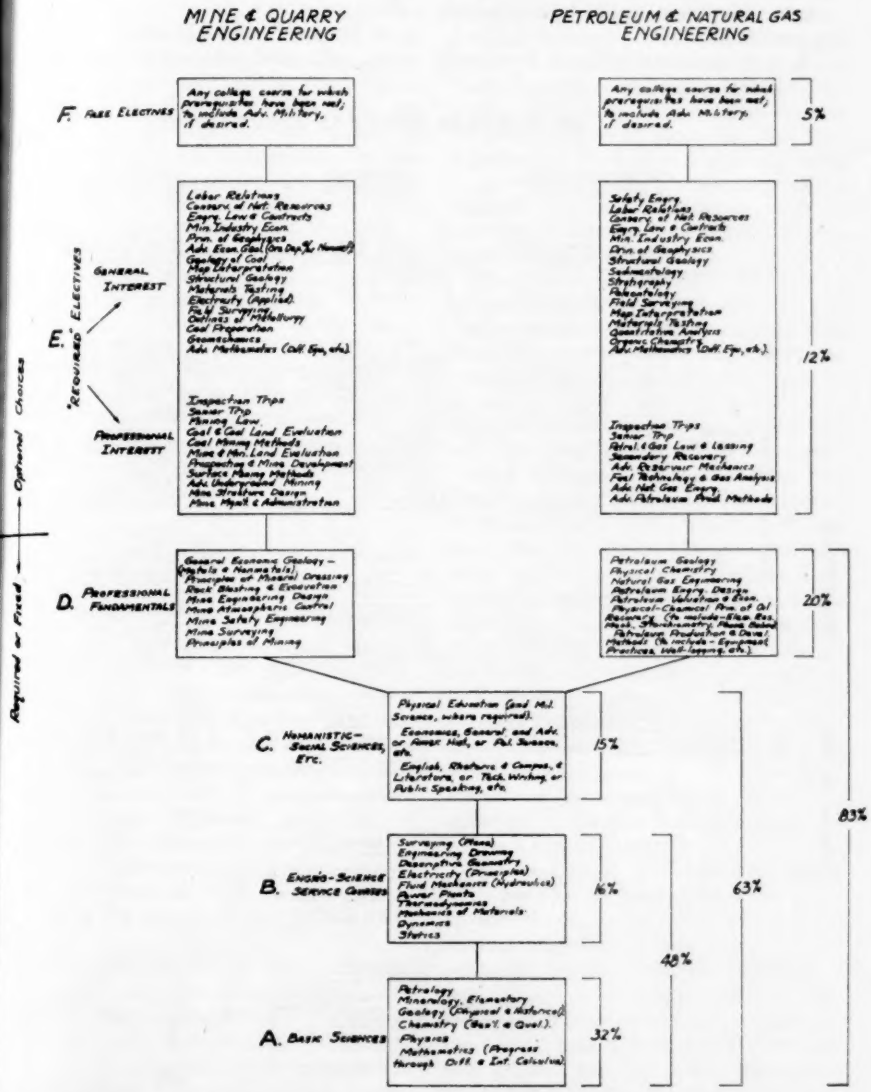
B. *Curriculum Requirements of the Engineering Branches of Mineral Industry Education.*

In the writer's opinion, there are several features that must attend any satisfactory engineering curriculum. Each is essentially of equal importance in the accomplishment of full, well-rounded training for professional service and citizenship. These objectives, in the final

I- MINERAL EXPLORATION ENGINEERING



II- MINERAL PRODUCTION ENGINEERING



analysis, are the ends sought by academic endeavor. The features are, namely:

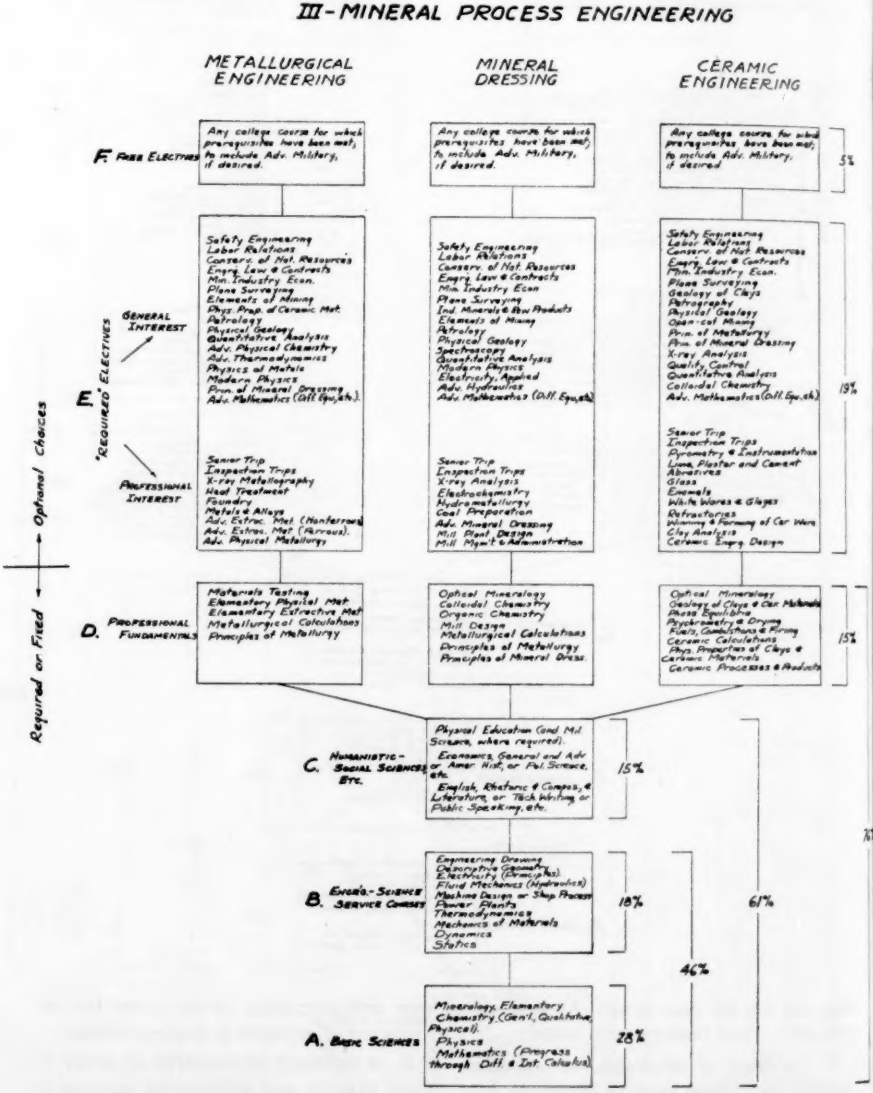
1. At least a modicum of specified training in culture such as literature, history and economics as the bases for assumption of citizenship responsibilities.

2. A sufficient requirement of study in basic sciences and engineering sciences to

insure an able, thorough understanding of how such knowledge is applied to engineering, in general, and to a given branch, in particular.

3. A fundamental training in a given engineering field to prepare the individual with a foundation for successful professional practice.

4. Optional studies whereby the student, with qualified guidance, can select



a special channel of professional work for which he has a particular desire or aptitude.

5. A reasonable opportunity to gain knowledge of any sort in any field of interest that may be available for study in the given university or college. For example, the work can be, on occasion in such "foreign" or professionally remote subjects as music appreciation or drama. Contrary to the point-of-view held by many, it is the writer's belief that studies of this type may be as interesting, beneficial, and broadening to the engineer as they are to other students.

This analysis of minimum requirements for mineral engineering curricula has been predicated on the philosophy fixed and defined by the above controlling elements. As shown by the accompanying charts, all curricula within any major branch have a common root of:

A. Basic Sciences.
B. Engineering—Science Service Courses.
C. Humanistic—Social Sciences.

The various optional fields of interest in any particular curriculum are, in turn, so related as to have a common stock in D. Professional Fundamentals. For example, Blocks A, B, C, and D, as they have been developed for each curriculum and so depicted on the respective charts, are fixed for that curriculum. As a case in point, any Ceramic Engineer, regardless of whether his interest is specialization in Glass, in Refractories or in White Wares, etc., must have the basic training (Blocks A, B, C, D) common to all Ceramic Engineers.

A parallel situation is true for Mining Engineers and other specified curricula of all branches; a coal mining major will take the same basic training (Blocks A, B, C, D) as a man primarily interested in metal mining. The specialization, in any case, will develop by the judicious, guided selection of the courses designated as "Required" Electives in Block E and subjects listed there are to be chosen by the student in conference with his adviser. The selection for fixing a given curriculum should be pro-rated from both the Professional Interest portion and the General Interest section of the block, as a whole. That is, an ideal curriculum becomes one with a suitable, selected balance between the two portions of Block E. The Free Electives of Block F will allow for work in Advanced Military or will permit a nominal unrestricted choice of study in any field of interest regardless of the so-called foreign character it may have.

The procedure outlined above has an inherent flexibility and a student with particular talents, aptitudes or desires thus is able to enjoy the opportunity to extend and direct his academic training while he is simultaneously acquiring a basic, required engineering knowledge. The reader will note that some subjects such as Quantitative Analysis, and Wet and/or Fire Assaying are not included as requirements in some curricular areas where often they have been previously placed. The primary reasons why these deletions have been made are: a. These courses are usually of "cook book" character rather than of engineering caliber, at least so far as the method of presentation is concerned. b. Progress in technology and its engineering application no longer requires such work as might have been deemed necessary some years ago. For example, the present-day lack of a need of assaying technique by the practicing Mining Engineer is a case in point.

It seems to be the consensus among educators that at least 4 academic years of college study are necessary to train mineral engineers of any branch. This commonly results in the acquisition of a total of about 150 credit hours wherein 1 credit has been earned for each recitation-lecture hour a week and 1 credit has been granted for each 3-hour laboratory period a week. The distribution of work may be made on the basis of the so-called semester plan or the quarter system. In any case, it involves about 8½ months of college study during each year of a 4-year

period. The actual time devoted to instruction through each of the 8½ month periods approximates 32 weeks. However, because the total of credits required for a B.S. degree is not standard in all schools, the logical approach to an overall analysis of the type that is here undertaken is to allocate the various units of training on a percentage basis. This is a legitimate and necessary procedure as the range of hours that develops is not primarily because of major differences in the character of courses but rather is in the number of hours devoted to specific subjects. The various items of subject matter given on the charts are to be construed to represent the nature of recommended course work rather than necessarily being particular courses. That is, one school may see fit to identify some subject material by slightly different terminology than another institution and, hence, an effort generally has been made to make the chart listings those of descriptive character instead of specific designations.

The percentages of study depicted for various units on the charts should not be interpreted as being absolutely inflexible. This is because it is recognized that some leeway of one, two, or even three percentage points may exist in any given study area of mineral engineering at any particular school. Such a situation does not imperil the pertinency of this present analysis nor does it necessarily reflect an unacceptable or untenable balance of subject matter at the given academic institution where slightly different percentage relations may be in effect.

The writer has studied the controls which theoretically are applied in evaluating Chemical Engineering curricula. These statistics, as listed in "The Development of Chemical Engineering Education in the U. S. by the Committees on Chemical Engineering Education of the A.I.Ch.E." (p. 21), are:

Chemistry	25–30%
Chemical Engineering	20–15%
Other Engineering	12%
Mathematics	12%
Physics	8%
Mechanics	6%
Other Sciences	2%
Cultural Subjects	15%

The analysis of these percentage data by breaking them down as logically as possible into comparable units with those which have been used in this present study and, similarly, by taking an average of the units of the three major Mineral Engineering branches, gives the following comparison:

	Chemical Engineering		Mineral Engineering
A. Basic Sciences	Chem. 25%, Physics 8%, Math. 12%	45%	31%
B. Engineering-Science Service Courses	Mech. 6%, Other Sci. 2%, Other Engrg. 12%	20%	17%
C. Humanistic-Social Studies		15%	15%
D. Profession Fundam.	(Chem. Engrg.)	20%	17%
E. "Required" Electives		0	14%
F. Free Electives		0	5%
		100%	99 + %

So far as is known, Chemical Engineering is the only field of engineering training in which curricular requirements previously have been established and specifically given. It is apparent that such controls as have been used for evaluating and accrediting this branch of engineering are much more inflexible than those herewith proposed for all branches of Mineral Engineering. As previously discussed,

this rigidity of a course of study is, in the writer's opinion, an undesirable characteristic. Anyone who is well educated in engineering is trained in the basic sciences, and in special professional areas and, likewise, has had an opportunity to acquire some background of learning as a reasonably cultured citizen. A fully educated person has not been developed if any of these essential elements are lacking.

Conclusion

The foregoing text of this report proposes:

A. Branches of work that should be recognized as of enginering character in Mineral Industry Education and;

B. Minimum course-of-study requirements that should obtain to in any curriculum of Mineral Industry Education.

Your committee recommends the adoption of the proposals by the Mineral Division, ASEE. If this recommendation is accepted, it means, of course, that any school seeking accreditation will be expected to meet the various designations and respective curricular requirements. Thus, guides will be available to engineering institutions to aid in establishing curricula and, likewise, examining boards will have controls in effect to govern their decisions concerning the status of courses of study.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Is Closer Integration an Answer to Crowded Curricula?*

By PROFESSOR JOHN J. TURIN

Head of the Department of Physics, University of Toledo

There has been no clear agreement on the basic objectives of the undergraduate engineering curriculum. There are many opinions and a wide divergence in ideas. There are some who think the training should be broad and basically scientific with added specialization in post-graduate work. Others think the program should be highly specialized because of the necessity for presenting a vast amount of information in each field of specialization. Some insist that the engineer needs far more exposure to the humanistic and social studies. Many agree, but argue there just is not the space available in the already crowded curriculum.

Primarily we are faced with the problem of determining the objectives of engineering education in a civilization whose complexion is changing at an extremely rapid rate. Engineering educational objectives must be realistic and malleable. They must take into account the technological changes of our times, but they cannot be all inclusive. Similarly they must not be oblivious to the social impact of our technical progress, nor can they ignore the impact of these changes upon the student.

There are many pressures caused by a variety of different problems, each of which will ultimately exert its influence in determining the objectives of future curricula in undergraduate engineering education. The literature is abundant with discussions, each trying to give proper weight to some one of a number of factors important in the training of engineers. No doubt evolution and necessity will gradually produce clarification and more common agreement regarding the objectives of engineering curricula.

There seems however to be general agreement that the engineering curriculum is crowded. So crowded in fact, that there appears serious doubt as to whether it is possible to include even short introductions to some of the basic new concepts which have recently developed in the engineering field. As a matter of fact, the inclusion of any new topic requires the exclusion of a topic presently in the curriculum, and this of course, raises questions regarding the relative importance of each subject.

No matter how we change the basic objectives of engineering education over the long term, we all realize that what can be done in the various specialties and on the higher level is influenced to a great degree by the preparation of the student in the high schools and in the introductory courses to the engineering curriculum. We would all agree that many of our curricular problems would fade if the entering student were better prepared. Quite obviously we are not free to determine college entrance requirements in a fashion oblivious to the problems of the high school, but MacDonald [1] and Rose [2] are

* Presented at the Ohio Section Meeting of ASEE at Cincinnati, May 2, 1953.

[1] MacDonald, C. E., "The Future Prospects of Improved Preparation for College," *Journal of Engineering Education*, 42, p. 432 (1952).

[2] Rose, L. A., "A Joint Attack on the Mathematics Entrance-Requirements Prob-

encouraging along this line. Certainly we must extend a cooperative hand to the high schools and help to raise the level as well as the interest of the entering engineering student.

In our college curricula perhaps we should consider a closer integration of the introductory engineering subjects to obtain a more efficient use of the early years, thus effectively lengthening the period for higher level training.

The Thinking Process

There is one basic educational objective which too often we take for granted. The engineer *must learn to think properly.* For if he fails in this, all other items in his training are of secondary importance.

The thinking process is complex, and must be clearly distinguished from the "ability to read, to listen and to retain facts."[1] Doughtery[3] suggests:

> "To teach one to think is the highest possible teaching achievement. It comes from a combination of understanding, memory, association, application of laws, and ability to sense possible relationships."

All agree that the educational processes leading to the prevocation and practice of thinking must be encouraged from the earliest possible moment. Yet our curricula are not too often calculated to help the process, and often do the opposite.

The "technical thinking" of the engineer is a highly specialized process, which requires a clear and concise appreciation or how mathematics and a fundamental understanding of natural phenomena can be fused together and applied to tasks of usefulness and value to society with a minimum of "cut and try." To develop this thought process requires a proper cultivation of the "will to do" and a realization on the part of the student that mastering this thought process will help simplify his problems and not constitute an added difficulty.

A closer integration of the introductory courses with the objectives of bringing the student to a more confident and more mature development in "technical thinking" at the earliest possible time should be worthy of careful consideration. For what the student is taught at the start is the basic platform upon which all else must stand. It is essential that the student be introduced to proper and productive thought discipline from the very beginning so that it will not be necessary to apply successive and alternative corrective procedures.

From this standpoint, perhaps we have been giving far too little attention to the introductory portions of engineering education and concentrating too much on how we can get adequate coverage in the more specialized fields of engineering.

Introductory Courses

Barker[4] suggests that we abandon the idea that elementary and introductory courses should be taught by junior instructors and teaching assistants. For here is the most difficult job, and where we can make the greatest gain.

There is good reason to insist that the introduction to engineering must be given by our most experienced and mature minds, by those who are intimately familiar with the purposes of the introductory courses and the nature of the problems the student will ultimately encounter in pursuing his engineering goals.

It is imperative that the objectives of the introductory courses, and the disciplines which they encompass be brought to the student in an inspiring way, provocative of thought. In this way the student will enjoy these introductory courses and come to an earlier appreciation of the value of the disciplines inherent in them. He will be more confident that he has acquired a useful ally and a friend,

lem," *Journal of Engineering Education*, 42, p. 412 (1952).

[3] Doughtery, N. W., "Educational Maturity is the Goal," *Journal of Engineering Education*, 41, p. 271 (1951).

[4] Barker, George J., "Four Year vs. Five Year Engineering Course," *Journal of Engineering Education*, 42, p. 460 (1952).

and will not look upon the introductory courses as just another obstacle he must overcome.

If the elementary preparations are adequately achieved and the discipline of mathematics is properly integrated into the "technical thinking" process during the introductory courses, the advanced subjects can be mastered more easily by the student and in less time without constant repetition and duplication.

As an example, too often the student thinks of his mathematics and physics as something apart from engineering— a necessary evil which he must put up with in order to be allowed to study what he is really interested in—and something to be forgotten at the earliest possible moment.

As accumulated knowledge increases the various aspects of engineering become successively more highly technical, and should the pace of progress continue, this will become more and more magnified as time goes on.

This situation requires of the student an ever greater familiarity with applied mathematics and physics on a higher and higher technical plane if he is ultimately to cope with the new engineering problems which will confront him.

Costly Methods

During the past years because of the immaturity of the student in applied mathematical thought we have used methods for teaching physics and engineering subjects which circumvented the need for a proper understanding of applied mathematics even in its most simple forms. These methods are extremely costly in time, and it is questionable whether we can longer afford the luxury of taking extra time to teach and re-teach an engineering principle that can be taught with greater rigor and better understanding if the student's command of applied mathematics and physics has been properly developed.

It seems reasonable to believe that a fundamental contribution can be made generally to all engineering curricula by giving careful attention to the introductory courses and applying the necessary measures which will result in a close integration of the introductory courses to the ultimate specialized subjects.

Experience certainly indicates that if mathematics and even physics are taught as pure sciences without detailed reference to engineering application, that it is difficult thereafter to demonstrate to the student how these sciences can be fruitfully considered a basic part of engineering.

There is no time for details in a short discussion such as this. However any measure which can help the student to a more mature mind earlier in his college training will enable him to learn more quickly. Within limitations of course, closer integration of the introductory courses to the engineering courses can have the effect of lengthening the time for study and therefore easing the crowded curriculum. This procedure should additionally help the student to acquire at an earlier date that "judgment"[5] which is so essential to the successful engineer.

[5] Sherwood, Thomas K., "Should Engineering Schools Teach Engineering?", *Journal of Engineering Education*, 43, p. 383 (1953).

The General Mode of Analysis in Engineering Education*

By L. M. K. BOELTER, *Dean of Engineering, University of California at Los Angeles*
and
G. A. HAWKINS, *Dean of Engineering, Purdue University*

The undergraduate engineering student is constantly confronted with the analysis and synthesis of engineering problems from the time he enters the freshman year until graduation. Many of these young engineers do not appreciate the fact that there is a general mode applicable to many areas of engineering; and hence develop an attitude of mind that each type of problem is solvable only by a special technique. It is, therefore, important in the educational experience of the engineering student to introduce the general mode early in the program and continue a thorough integration of the basic mode throughout all of the remaining work. By continuous employment of the general mode the student acquires skill in its use, and forms a habit which will last throughout his professional engineering career.

The first phase of the program of familiarizing the student with the general mode of analysis is to make him aware of the difference between the actual and the ideal engineering system. Due to the complexity of present day engineering machines, structures, processes, and circuits, it is difficult—and in many instances impossible—to analyze and synthesize them without introducing simplifying assumptions and postulates. In order to consider an actual engineering system the engineer must devise an ideal or mental concept based on certain suppositions, which he then studies in place of the actual device.

* Paper prepared for the sixty-first Annual Meeting of the ASEE, June 22–26, 1953, Gainesville, Florida.

As a final step in the consideration of the system, the engineer must predict the behavior of the real or actual system from the results obtained from his ideal or mind system. This latter step requires a great deal of actual experience, which is usually acquired after graduation. Because of limited time and other factors it is only possible to impress upon the undergraduate engineering student the importance of post graduate experience with various engineering systems.

Ideal System

In order to illustrate the use of the ideal or mind system for the prediction of the behavior of the actual system, imagine that the engineering student has been called upon to estimate the elongation of a vertical structural steel bar when acted upon by a given tensile force. Before the student is able to apply fundamental laws or basic facts he must establish an ideal system based on postulates such as the following: the tensile force is applied along the exact longitudinal axis of the bar; no bending of the bar occurs; the bar material is homogeneous; the thermal environment surrounding the bar remains constant; all elemental fibers of the bar undergo the same elongation; the proportional limit of the materials in the bar is not exceeded; the weight of the material is negligible in comparison to the load.

Having established a mental picture of the ideal system, the student is in a position to apply Hooke's experimental law

and predict the elongation of the ideal bar. Based on previous experiences with other actual systems (this may be lacking as far as the student is concerned), he must decide as to how accurately the elongation of the ideal bar will represent that for an actual rod.

The majority of experienced engineers established the ideal system on the basis of simplifying postulates with little ado. They become so accustomed to dealing with the idealized case that they seldom think of it as a separate step in the procedure of analysis or synthesis.

General Procedures for Studying the Behavior of Engineering Systems

Having been introduced to the concept of the ideal and actual systems, it is then possible to show the student how the ideal or mind picture fits into the general procedures used by engineers in the study of complicated engineering systems. It is felt that the six following steps are generally used by engineers in the study of engineering systems:

1. The preparation of a complete statement of the problem associated with the actual system.
2. The establishment of an ideal or mind system based on
   (1) direct observations or a familiarity with the actual system,
   (2) direct observations or a familiarity with similar ideal or actual systems.
3. Specification of the boundaries of the ideal or mind system.
4. The application of the fundamental laws or basic knowledge in order to obtain the behavior of the ideal or mind system.
5. The prediction of the behavior of the actual system from the results obtained on the ideal or mind system.
6. The study of additional ideal systems if greater accuracy is required in predicting the behavior of the actual.

The results obtained using the first ideal system may not be sufficient in extent or have the desired accuracy in order to predict the behavior of the actual system. In this event a second mind or ideal system must be formulated and analyzed on the basis of fewer or new postulates. As the number of mind systems is increased the behavior of the actual system may be more accurately portrayed from the analysis of the ideal cases. From a theoretical standpoint, if the number of mind systems becomes infinite, the behavior of the actual and ideal systems become one and the same. The number of ideal systems which an engineer may wish to use will depend upon such factors as economic limitations, available time, the knowledge of the engineer, and the knowledge of society in general.

The general mode of analysis becomes unique to engineering when the solutions are considered in terms of time, cost, materials, and men. For example during war periods, time and men may be more significant than cost or materials, hence the engineer must give serious consideration to these factors in his analysis.

Specific Modes of Analysis

Specific names may be used to describe the general method of study by referring to the laws and knowledge employed in the fourth step. If basic economic laws are applied, then the method could be termed the economic mode of analysis. The mode of analysis used by engineers in the study of energy conversions may be termed the "thermodynamic method of analysis," and would encompass the application of the laws of thermodynamics in step 4.

Approaches Used in the General Mode of Problem Solution

Having impressed upon the student the importance of the general procedure, it is important to acquaint him with the four procedures used by engineers, which follow:

1. *Analytical*—The analytical approach consists of applying and solving mathe-

matical equations based on physical laws. By employing suitable techniques and computing facilities, satisfactory solutions for the equations may be obtained for use in predicting the behavior of some engineering systems.

2. *Experimental*—This approach covers experimental determination and prediction of the behavior of the engineering system.

3. *Art*—In many problems encountered by the professional engineer the force fields may be very extensive or even unknown, and hence they cannot be treated analytically or experimentally. In these instances the knowledge of the engineer, which may be based on scientific training and greatly amplified by practical experiences, enables him to predict the behavior of an actual system. The professional engineer is able to sense the variables involved, which cannot be analyzed or formulated by the scientist who lacks his experience. Usually the engineer has available a large amount of unformulated knowledge gained by experiences with many actual systems upon which he may draw.

4. *Models and Analogues*—This approach consists of establishing a model or analogue which may be used to predict the behavior of the actual system. In many instances the model method is used in conjunction with the experimental and analytical methods.

In the study of many engineering problems it is often necessary to use a combination of two or more of the methods in order to predict the behavior of the actual system. The ability to use the four methods independently or in combinations greatly expands the engineer's skill to predict the behavior of an actual from an ideal system.

Too often young engineers acquire a feeling that one of the four methods is superior and more important than all of the others. It is our responsibility as practicing engineers to help and encourage engineers in training to become proficient in the use of the four methods. In so doing we will enhance their education and strengthen the profession.

Before successful integration of the general mode can be attained, the complete cooperation of the individual faculty members must be obtained. Unless the staff members are sympathetic toward the educational project, very little can be accomplished. The student can only acquire the necessary skill in the use of the general mode if the instructors in the freshman, sophomore, junior, and senior years insist upon the application of the basic principles to the solution of problems in their particular courses. Only after employing the principles in various courses will the student acquire the necessary skill and confidence in the system of analysis and synthesis.

New Members

ANDERSON, LEMOYNE W., Counselor Librarian, University of Illinois, Chicago, Ill. M. V. J. Dembski, F. W. Trezise.

BENNET, ALEXANDER SHARP, Special Instructor in Drawing, University of Texas, San Antonio, Texas. Jack Lenhart, N. C. McGuire.

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BOOTH, NORWOOD S., College Employment Supervisor, Illinois Bell Telephone Company, Chicago, Ill. W. C. Hall, K. J. Howard.

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Caveny, Charles Claire, Executive Dean, University of Illinois, Chicago, Ill. M. V. J. Dembski, H. R. Goppert.

CHANCE, CLAYTON WILLIAM, Instructor in Drawing, University of Texas, Austin, Texas. J. D. McFarland, Jack Lenhart.

DE CHAZAL, LOUIS EDMOND MARC, Assistant Professor of Chemical Engineering, University of Missouri, Columbia, Mo. R. H. Luebbers, H. O. Croft.

CROSS, RAYMOND EDWARD, Instructor in Management, DePaul University, Chicago, Ill. R. S. Lindenmeyer, B. H. Jennings.

DEFILIPPS, ANTHONY J., Assistant Professor of Architecture, University of Illinois, Chicago, Ill. M. V. J. Dembski, S. E. Shapiro.

DERRICK, LUCILE, Associate Professor of Economics, University of Illinois, Urbana, Ill. M. V. J. Dembski, D. M. Holloday.

FOSTER, ROBERT CARL, Instructor in Mathematics and Science, Tri-State College, Angola, Indiana. P. A. Nurnberger, Alice Parrott.

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MAJDE, STEFAN, Research Supervisor, Askama Regulator Company, Oak Park, Illinois. M. V. J. Dembski, J. S. Kozacka.

MATTICE, HUBERT CLAUDE, Assistant Professor of Aeronautical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. Paul Lieber, R. P. Harrington.

MAYOR, JAMES WATT, JR., Assistant Professor of Mechanical Engineering, Northeastern University, Boston, Mass. F. S. Stearns, A. J. Ferretto.

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NORTON, MAURICE EARL, Recruiting Regional Manager—Technical Personnel, General Electric Company, Schenectady, N. Y. I. M. Bowning, D. S. Roberts.

PALMER, ARTHUR IRVING, JR., Instructor in Civil Engineering, University of Virginia, Charlottesville, Va. C. N. Gaylord, E. C. McClintock.

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RIGLER, MATTHEW L., Director of Speech Clinic, University of Illinois, Chicago, Ill. F. W. Trezise, M. V. J. Dembski.

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SLABY, STEVE M., Assistant Professor of Graphics, Princeton University, Princeton, N. J. F. A. Heacock, A. L. Bigelow.

SMITH, ALLEN N., Assistant Professor of Engineering, San Jose State College, San Jose, Calif. J. B. Franzini, G. S. Emmerson.

STEVENS, ALBERT BYRON, Head of Department of Petroleum Engineering, A. & M. College of Texas, College Station, Tex. A. R. Burgess, B. F. K. Mullins.

TEMMER, HAROLD EDWARD, Examiner and Recorder, University of Illinois, Chicago, Ill. A. B. Bronwell, M. V. J. Dembski.

VITTUM, HENRY E., Instructor in English, Newark College of Engineering, Newark, N. J. J. H. Pitman, N. A. Estrin.

WEAVER, PAUL, Professor of Geology, A. & M. College of Texas, College Station, Texas. S. A. Lynch, A. B. Stevens.

269 new members elected this year

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Library of Congress	Feb. 2, 1954	C. H. Walther, George Washington University
New England	Massachusetts Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

* **No Date Set.**

Report of the National Security Training Commission on UMT

The National Security Training Commission, appointed by the President to make recommendations respecting Universal Military Training, submitted its report on December 14. This will be considered by Congress shortly after it convenes in January. The principal features of the Report might be summarized as follows:

1. All physically fit males should share in the obligation to serve the nation.

2. The present reserve system has drawn too heavily on veterans of World War II and is therefore unfair. More than 600,000 veterans of World War II who were in the reserve were involuntarily recalled to duty in the Korean War, whereas prior to June, 1950, 2½ million of the 3½ million physically fit young men who became 18 between World War II and the start of the Korean emergency saw no service. This policy is morally wrong and financially costly.

3. If the armed forces are maintained at 3,360,000 which is highly unlikely, through 1960, there will be over 2 million fit young men who will not have served. There are about 1,600,000 fit young men of military age who have not seen service as of now.

4. All fit young men of 18 should be required to enter the National Security Training Pool upon registering with the Selective Service System.

5. After six months of basic and technical training, National Security Trainees would be transferred to the reserve for 7½ years and would be liable to recall ahead of veterans.

6. Veterans of the present emergency who have served two years or more should be transferred out of the Ready Reserve to Standby Status upon request as the national security permits.

7. The reserve obligation of young men who undertake certain professional and technical training should be held in abeyance until the completion of such training, if they so desire.

8. Young men should draw lots upon registering with the Selective Service System to determine whether they will be liable for training or service and should be notified of the result immediately.

9. Permissive deferments now possible under Selective Service would be disallowed for induction for the training period. Students and industrial workers would be given some latitude in deciding when their service or training is to start.

10. Induction of young men in college would be delayed until the end of the current academic year.

11. ROTC students who have signed a contract would be deemed to have fulfilled their obligation for training.

12. National Security training would begin by January, 1955 or earlier, with at least 150,000 trainees.

13. National Security trainees should receive not more than six months and not less than 1050 hours of training.

Recommendations of Engineering Manpower Commission

The Engineering Manpower Commission of the Engineers' Joint Council has recommended that the training period be reduced from six months to four months and that it be coordinated with the college program for individuals interested in higher education. They also recommended that trainees be returned to civilian status after the training period and be subject

to recall only by the Selective Service System. This would make it possible to call up trainees on the basis of the overall needs of industry, the country, and the military services.

They also recommended that study be started immediately of the problem of a voluntary, dependable, immediately available reserve apart from consideration of UMT. The ASEE is working with the Engineering Manpower Commission and the American Council on Education in preparing recommendations respecting this program.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

HEAD OF CIVIL ENGINEERING, STRUCTURAL ENGINEER WITH ADVANCED (preferably doctors') degree with good record of publications and research. Age 35–45. Large eastern university with opportunities for sponsored research and outside consulting. Applicant must be able to teach advanced graduate courses. Inquiries will be kept confidential. JA–1.

INSTRUCTOR OR ASSISTANT PROFESSOR OF ELECTRICAL ENGINEERING (Power). At least B.E.E. required. Appointment immediately or February, 1954. Apply to Dean, School of Engineering, University of Virginia, Charlottesville, Virginia.

Engineering Enrollments and Degrees, 1953*

By HENRY H. ARMSBY and WILLIAM A. JARACZ**

Engineering enrollment has increased for the second consecutive year—after successive annual declines from a post-World War II high of 244,390 in 1947 to a post-World War II low of 147,694 in 1951. The 171,832 students currently enrolled in engineering schools accredited by the Engineers' Council for Professional Development constitute an increase of 8.4 per cent over the number enrolled in the fall of 1952. This is much larger than the 4.8 per cent increase in total enrollment, and the 3.3 per cent increase in male enrollment, in all higher educational institutions. The latter comparison is perhaps the more valid one, inasmuch as engineering enrollment consists preponderantly (99.5 per cent) of men students. This fall's increase of 8.4 per cent constitutes, furthermore, an increase in the rate of increase in total engineering enrollment, in view of the fact that the increase from 1951 to 1952 had been 7.3 per cent.

A similar situation prevails in the case of new students. The gains experienced by engineering schools are considerably in excess of those for all higher educational institutions, the figures being 14.5 and 6.5 per cent, respectively. The 1953 freshman class of 52,482 students is the 3rd largest ever to enter the engineering schools. The size of the enrollment figure of new engineering students for this fall, as contrasted with the larger figures for 1946 and 1947, gains in significance when one considers the circumstances prevailing then and now. The socalled enrollment "bulge" immediately following World War II was the result largely of the materializing of a deferred demand for education on the part of a significant proportion of the population of college age, a factor which has no counterpart in current enrollment behavior.

Although a larger proportion of young people are entering college, the dimensions of this increase are not such as to explain the considerable increase in freshmen engineering students. The explanation must be found in the relatively stronger attraction which engineering disciplines have had for new students during the course of the past few years. This fall 9.2 per cent of all freshmen were enrolled in engineering schools as compared with 8.5 per cent last fall, 7.2 per cent in 1951, and 5.7 per cent in 1950. Many considerations, of course, underlie the choice by new students of engineering disciplines in preference to others. The ever increasing impact of mechanization and science on our civilization, to which the young are exposed at every hand, has, in a general way, a considerable effect. More specific factors are, however, to be found in the increased demand,

* All engineering data appearing in the text of this report are restricted to ECPD accredited schools. A report which lists all engineering schools, regardless of ECPD accreditation, will shortly be issued by the U. S. Office of Education.

** In the U. S. Office of Education, Department of Health, Education, and Welfare, Mr. Armsby is Chief for Engineering Education; and Mr. Jaracz is Head, Statistical Services Unit, Research and Statistical Standards Section. The authors would like to acknowledge their indebtedness for contributions made during the several stages in the preparation of this report to the following: Iola B. Morgan, secretary to Mr. Armsby; and Mabel C. Rice, Neva Carlson, Evelyn V. Williams, Hazel C. Poole, Leah W. Ramsey, and Mable S. Thomas—of the staff of the Statistical Services Unit.

widely publicized, for highly remunerated technical and scientific personnel; the opportunity for military reserve training with attendant commissions upon graduation; and the fact that deferment of military service until the completion of college training appears to be socially more palatable in the case of scientific and technical training.

The large number of freshmen engineering students this fall and last will undoubtedly be reflected in an increase in the number of engineering graduates in 1956 and 1957, assuming a stable rate of attrition. It is estimated that last year's entering class will yield 26,000 graduates in 1956, and this year's 30,000 in 1957. The outlook for the two intervening years is not nearly as bright, the estimates being 17,000 and 20,000 for 1954 and 1955, respectively. The small number of engineers who are expected to graduate during these latter two years, the result largely of small entering classes in 1950 and 1951, is likely to accentuate the acute shortage of civilian engineers in the years immediately ahead.

The number of undergraduate engineering students has also, as is the case with total engineering enrollment, increased for the second consecutive year. The 150,426 enrolled in the fall of 1953 represent an increase of 8.9 per cent over the previous fall's enrollment. In view of the fact that the increase from 1951 to 1952 was 7.6 per cent, the 8.9 figure constitutes an increasing rate of increase.

The undergraduate enrollment is distributed by level as follows: freshmen, 34.9 per cent; sophomores, 21.9 per cent; juniors, 15.9 per cent; and seniors, 14.5 per cent. Approximately 1.6 per cent are 5th year students pursuing 5-year programs, and the remaining 11.2 per cent are part-time and evening students. The number of students in this latter category declined by 2.3 per cent, after registering successive annual gains from 1950 through 1952.

About 55.3 per cent of all undergraduate engineering students are enrolled in 3 curricula: mechanical (20.9 per cent); electrical (20.5 per cent); and civil (13.9 per cent). The corresponding figures for 1952 were 55.2, 21.2, 19.3, and 14.7, respectively. This fall 86 schools reported unclassified students, as compared with 92 last fall, 84 in 1951, and 82 in 1950.

The number of male students upon whom undergraduate engineering degrees were conferred in 1952–53 is 20.3 per cent smaller than in the previous year. This compares with a decline of 11.5 per cent in all first degrees conferred on male students in all institutions. Of all first degrees granted to men students, 10.8 per cent were in engineering. The proportion was 11.9 per cent in 1951–52.

The distribution of first degrees among the three principal engineering curricula was as follows: mechanical, 5284; electrical, 4415; and civil, 4070. These three fields accounted for 24.4, 20.4, and 18.8 per cent of all engineering first degrees, respectively. Fewer degrees were conferred in each of these fields in 1952–53 than in 1951–52, the declines being 22.6 per cent for mechanical, 24.9 per cent for electrical, and 17.2 per cent for civil.

The increase in graduate enrollment continues unabated. In the fall of 1953, 5.7 per cent more students were enrolled for the master's or other pre-doctoral degree than in 1952. A similar increase was registered from 1951 to 1952, namely, 5.9 per cent. The number of students enrolled for doctorates increased 2.4 per cent. The increase from 1951 to 1952 was 1.9 per cent. About 56.1 per cent of the students working towards the master's degree are evening students, as compared with 57.4 per cent for last fall. A considerably smaller proportion (23.4 per cent) of students working for doctorates, on the other hand, are evening students. The figure for last year was 22.8 per cent.

The increase in the number of graduate students reflects the demand by industry for individuals with advanced training in engineering. This is especially evident when one considers the high proportion of the candidates for master's degrees who are enrolled as evening students. The majority of these are un-

doubtedly employed engineers who recognize the necessity of advanced training for bettering their understanding of the more complex engineering processes which are constantly being developed.

While the number of graduate students in engineering has increased, they represent a smaller proportion (12.5 per cent) of total engineering students. The figure for 1952 was 12.8 per cent, and for 1951, 13.1 per cent. The proportion for the college population as a whole is about 10 per cent.

About 31.4 per cent of all graduate engineering students are taking training in electrical engineering; 17.3 per cent in mechanical; and 11.3 per cent in chemical. The corresponding figures for last year were 30.2, 17.0, and 11.4 per cent, respectively.

The number of master's degrees conferred in engineering declined for the second consecutive year. There were 9.8 per cent fewer degrees conferred in 1952–53 than in the previous year. The decline in all master's degrees conferred was only 4.0 per cent. The number of doctorates conferred in engineering, on the other hand, increased 1.0 per cent, as compared with an increase of 8.1 per cent for all doctorates.

The data contained in this report are based on a survey of engineering schools and colleges made in October 1953, under the joint sponsorship of the U. S. Office of Education and the American Society for Engineering Education. In accordance with an agreement reached by the joint committee of the Office of Education and the ASEE, all institutions listed in the Office of Education Directory of Higher Education [1] which reported that they conferred degrees in engineering during 1952–53,[2] were requested to supply data. Ten Canadian institutions were also invited to participate in the study. This report presents enrollment and degree data for all institutions accredited by the ECPD, 61 other United States institutions, and 10 Canadian institutions.

As proposed by the joint ASEE and Office of Education Committee and approved by the ASEE general council, the tabulations in this report list individually only the ECPD accredited institutions (eligible for active membership in the ASEE), but contain data for the other U. S. institutions and for the Canadian institutions as a group.

Definition of Items:

Period covered: Engineering schools were asked to report student enrollment as of October 5, 1953. A few institutions, because of late opening, were unable to report before November. Degree data are for the period July 1, 1952 to June 30, 1953.

Undergraduate students: Institutions were requested to report by class level only those students enrolled definitely as candidates for an engineering degree. "Part-time students" (both day and evening) may include degree candidates as well as students who are not working toward a degree.

Graduate students: Institutions were requested to "Report all students who have been admitted to formal graduate courses—regardless of the number of credit hours carried by the students, and regardless of whether the student's work is administered by the engineering college or the graduate school."

[1] Education Directory, Part III, Higher Education, 1952–53.

[2] Earned Degrees Conferred in Higher Educational Institutions, 1952–53, Circular No. 380, U. S. Office of Education.

PRE-WAR AND POST-WAR COMPARISON OF ENGINEERING COLLEGE ENROLLMENTS

(for United States and outlying parts)

Undergraduate Enrollment

Year	Freshman	Sophomore	Junior	Senior	5th Year	Part Time and Evening	Total	No. of First Degrees
1940	33,175	24,242	20,120	16,310	985	14,079	108,911	11,358 (1939–40)
1947	57,507	71,615	48,227	32,369	1,846	18,616	230,180	18,592 (1946–47)
1948	47,672	52,949	59,945	45,695	1,924	17,932	226,117	27,460 (1947–48)
1949*	36,508	35,648	41,695	50,991	2,326	13,478	180,646	41,793 (1948–49)
1950*	29,394	27,242	30,957	37,707	3,150	14,504	142,954	48,160 (1949–50)
1951*	34,147	23,408	24,757	27,820	2,946	15,289	128,367	37,904 (1950–51)
1952*	45,854	26,636	22,369	23,453	2,563	17,295	138,170	27,155 (1951–52)
1953*	52,482	32,953	23,975	21,730	2,396	16,890	150,426	21,642 (1952–53)

Graduate Enrollment

	Master's Degrees and Other Pre-Doctoral Degrees					Doctor's Degrees				
Year	Full Time	Part Time	Evening	Total	Master's and Other Pre-Doctoral Degrees	Full Time	Part Time	Evening	Total	Doctor's Degrees
1940	2,003	980	1,599	4,582	1,318 (1939–40)	404	179	41	624	108 (1939–40)
1947	5,465	3,663	3,515	12,643	3,090 (1946–47)	704	784	79	1,567	127 (1946–47)
1948	6,138	2,348	4,882	13,368	4,303 (1947–48)	1,046	569	454	2,069	252 (1947–48)
1949*	6,277	4,056	4,746	15,079	4,783 (1948–49)	1,593	793	155	2,541	417 (1948–49)
1950*	8,150		7,425	15,575	4,865 (1949–50)	2,342		453	2,795	492 (1949–50)
1951*	6,878		9,574	16,452	5,134 (1950–51)	2,419		456	2,875	586 (1950–51)
1952*	7,422		9,996	17,418	4,132 (1951–52)	2,261		669	2,930	586 (1951–52)
1953*	8,084		10,321	18,405	3,726 (1952–53)	2,298		703	3,001	592 (1952–53)

	1940	1947	1948	1949	1950	1951	1952	1953
Total college enrollment in U. S.**	1,490,000	2,333,000	2,410,000	2,456,000	2,297,000	2,116,000	2,148,000	2,251,000
Engineering enrollment in U. S.**	113,497	244,390	241,554	198,266*	161,324*	147,694*	158,518*	171,832*
Per cent engineering to total	7.6%	10.5%	10.0%	8.0%*	7.0%*	7.0%*	7.4%*	7.6%*

* Includes only ECPD accredited institutions. ** Includes outlying parts

* Includes only ECPD accredited institutions. ** Includes outlying parts

Undergraduate Engineering Enrollment, by Curriculum, October 5, 1953

Engineering Curriculum	No. of Schools[1]	Total Number Enrolled for Their First Engineering Degree										Number of First Engineering Degrees Conferred 1952–53	
		1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
										Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Schools accredited by ECPD:													
Aeronautical	49	1,814	1,285	840	696	43	32	18	141	4,844	25	591	4
Agricultural	33	455	310	242	265	17	—	6	—	1,295	—	286	—
Architectural	30	1,036	735	502	609	216	27	14	23	3,111	51	570	5
Ceramic	14	123	128	76	116	11	—	5	—	452	7	116	—
Chemical	108	4,362	3,531	2,385	2,162	115	192	39	643	13,313	116	2,181	2
Civil	138	5,843	4,989	4,182	3,926	135	259	164	1,384	20,812	70	4,065	5
Electrical	137	9,280	7,985	5,426	4,460	135	313	287	3,030	30,848	68	4,410	5
Engineering Mechanics	2	—	24	11	7	—	—	—	—	42	—	9	—
Engineering Physics	32	388	370	330	252	32	5	3	12	1,374	18	240	—
General Engineering	23	993	806	561	539	—	—	5	894	3,789	9	549	—
Geological	23	369	266	219	253	7	—	2	1	1,111	6	217	—
Industrial[2]	60	1,100	1,304	1,147	1,289	60	46	42	238	5,203	23	1,242	1
Mechanical	134	8,988	7,721	5,970	4,981	278	382	231	2,839	31,325	65	5,279	5
Metallurgical	47	496	523	482	558	18	17	9	198	2,292	9	542	—
Mining	29	292	222	228	270	10	—	—	5	1,027	—	288	—
Naval Arch. & Marine	3	30	51	45	54	—	—	2	—	182	—	51	—
Petroleum	23	1,337	845	690	668	28	—	10	40	3,615	3	564	1
Sanitary	7	20	15	18	40	—	—	—	—	92	1	15	—
Textile	6	287	146	141	127	—	—	15	—	713	3	77	—
Unclassified	86	14,879	1,311	108	10	—	—	676	5,624	22,367	241	2	—
Other	43	390	386	372	448	16	2	145	145	1,852	52	318	2
Total ECPD	149	52,482	32,953	23,975	21,730	1,121	1,275	1,673	15,217	149,659	767	21,612	30
Other U. S. Schools	61	7,996	4,093	2,817	2,428	4	225	624	3,112	21,250	49	2,519	3
All U. S. Schools	210	60,478	37,046	26,792	24,158	1,125	1,500	2,297	18,329	170,909	816	24,131	33
Canadian Schools	10	2,244	1,754	1,203	1,216	241	—	4	—	6,649	13	1,165	3
Grand Total (U. S. and Canada)	220	62,722	38,800	27,995	25,374	1,366	1,500	2,301	18,329	177,558	829	25,296	36

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Includes administrative engineering, management engineering, etc.

Graduate Engineering Enrollment, by Curriculum, October 5, 1953

Engineering Curriculum	No. of Schools[1]	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1952–53		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[2]				No. of Post-Grad. Degrees[2] Conferred in Eng'g 1952–53		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1952–53	
		Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
				Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
ECPD accredited schools:																			
Aeronautical	37	406	354	758	2	189	1	31	—	31	—	21	—	106	51	155	2	29	—
Agricultural	23	93	—	93	—	48	—	—	—	—	—	3	—	16	—	16	—	5	—
Architectural	13	38	2	40	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Ceramic	13	65	—	61	4	24	—	—	—	—	—	—	—	33	—	33	—	7	—
Chemical	83	878	982	1,840	20	430	3	3	—	3	—	—	—	475	91	565	1	147	—
Civil	93	1,054	912	1,956	10	559	1	17	—	17	—	13	—	170	40	209	1	32	—
Electrical	96	1,823	4,017	5,827	13	861	1	76	3	79	—	14	—	539	259	797	1	128	4
Engineering Mechanics	27	162	81	243	—	51	—	—	—	—	—	1	—	89	20	108	1	24	—
Engineering Physics	17	169	149	312	6	70	1	1	—	1	—	3	—	83	26	107	2	26	—
General Engineering	8	227	72	299	—	25	—	—	—	—	—	—	—	47	—	46	1	4	—
Geological	15	111	—	107	4	33	—	—	—	—	—	—	—	21	—	21	—	8	—
Industrial[3]	40	528	936	1,459	5	212	3	2	—	2	—	7	—	33	61	94	—	3	—
Mechanical	93	1,293	2,030	3,317	6	602	1	47	3	50	—	19	—	253	81	333	1	78	—
Metallurgical	40	253	349	600	2	122	1	4	—	4	—	3	—	190	62	251	1	56	—
Mining	19	53	1	54	—	19	—	2	—	2	—	3	—	6	—	6	—	1	—
Naval Arch. & Marine	3	28	—	28	—	8	—	92	—	92	—	19	—	—	—	—	—	—	—
Petroleum	15	143	6	138	11	31	—	—	—	—	—	1	—	5	—	5	—	4	—
Sanitary	12	72	4	76	—	44	—	—	—	—	—	1	—	31	6	37	—	4	—
Textile	4	21	—	20	1	14	—	—	—	—	—	—	—	2	—	2	—	2	—
Unclassified	20	85	142	223	4	71	—	—	—	—	—	—	—	16	—	16	—	—	—
Other	29	304	278	574	8	185	3	3	—	3	—	—	—	183	6	186	3	30	—
Total ECPD	123	7,806	10,315	18,025	96	3,603	15	278	6	284	—	108	—	2,298	703	2,987	14	588	4
Other U. S. Schools	3	15	187	202	—	17	—	—	—	—	—	—	—	—	—	—	—	—	—
All U. S. Schools	126	7,821	10,502	18,227	96	3,620	15	278	6	284	—	108	—	2,298	703	2,987	14	588	4
Canadian Schools	9	166	—	166	—	87	—	—	—	—	—	—	—	66	—	66	—	18	—
Grand Total (U. S. and Canada)	135	7,987	10,502	18,393	96	3,707	15	278	6	284	—	108	—	2,364	703	3,053	14	606	4

[1] This refers to the number of schools offering given curriculum. Such curriculum may or may not be specifically approved by ECPD.
[2] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[3] Includes administrative engineering, management engineering, etc.

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.

[2] Includes administrative engineering, management engineering, etc.

Total Undergraduate Engineering Enrollment, by School, October 5, 1953

Institutions	Total Number Enrolled for Their First Engineering Degree										Number of First Engineering Degrees Conferred 1952–53	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ECPD accredited schools:												
Alabama												
Ala. Poly.	782	416	252	215	—	—	3	—	1,664	4	208	—
Univ. Ala.	335	202	108	92	—	—	3	506	1,239	7	113	—
Arizona												
Univ. Ariz.	291	199	171	144	—	—	6	—	805	6	119	—
Arkansas												
Univ. Ark.	203	187	95	97	—	—	6	5	590	3	89	—
California												
Calif. Tech.	168	61	71	58	—	—	—	—	358	—	61	—
Santa Clara	89	68	48	41	8	—	—	—	254	—	44	—
Stanford	334	168	126	122	—	—	—	—	750	—	109	—
Univ. Calif. (B)	272	303	454	397	—	6	—	—	1,427	5	417	—
Univ. Calif. (L.A.)	291	248	231	153	—	—	1	—	921	3	118	—
Univ. Southern Calif.	155	141	298	316	—	—	—	622	1,528	4	217	—
U. S. Naval PG Sch.[1]	—	—	243	185	—	—	—	—	428	—	75	—
Colorado												
Colo. A. & M.	190	98	85	67	—	—	—	—	440	—	64	—
Colo. Mines	274	212	143	184	—	—	—	—	811	2	178	—
Univ. Denver	75	71	60	74	—	1	15	11	306	1	76	—
Univ. Colo.	571	384	297	223	20	—	24	466	1,965	20	233	2
Connecticut												
U. S. Coast Guard	181	135	108	99	—	—	—	—	523	—	86	—
Univ. Conn.	424	230	131	112	—	—	—	—	894	3	95	—
Yale Univ.	—	245	181	172	—	—	—	—	598	—	178	—
Delaware												
Univ. Delaware	164	125	77	61	—	—	—	—	424	3	58	1
Florida												
Univ. Florida	803	401	197	162	—	—	—	—	1,561	2	143	—
Georgia												
Ga. Tech.	1,597	802	518	538	25	—	—	—	3,472	8	604	—
Idaho												
Univ. Idaho	217	156	114	76	—	—	—	—	561	2	74	—
Illinois												
Bradley	132	91	66	64	—	—	12	26	389	2	53	—
Ill. Inst. Tech.	373	256	274	257	—	11	9	3,563	4,611	132	347	—
Northwestern	207	191	139	107	—	103	19	47	811	2	125	—
Univ. Ill.	1,887	1,056	687	416	36	—	—	—	4,063	19	535	—

Total Undergraduate Engineering Enrollment, by School, October 5, 1953—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										Number of First Engineering Degrees Conferred 1952–53	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Indiana												
Notre Dame	501	329	238	176	16	—	—	—	1,260	—	193	—
Purdue	1,510	1,006	729	715	—	—	423	—	4,357	26	629	3
Rose Poly	134	91	64	40	—	—	3	—	332	—	58	—
Iowa												
Iowa St. Coll	1,086	655	414	258	—	—	4	—	2,399	18	267	1
St. Univ. Iowa	153	114	65	68	—	—	—	—	399	1	75	—
Kansas												
Kan. St. Coll	392	199	121	169	—	—	—	—	879	2	152	—
Kan. Univ	363	260	242	205	—	—	2	—	1,062	10	156	1
Wichita	308	127	67	45	—	—	—	—	545	2	15	—
Kentucky												
Ky. Univ	415	269	143	142	—	—	20	—	987	2	98	—
Louisville	163	106	81	63	—	81	3	—	497	—	89	—
Louisiana												
Louisiana Poly	363	100	89	60	—	—	2	—	613	1	34	—
Louisiana St. Univ	649	268	227	206	—	—	—	—	1,345	5	157	1
Tulane Univ	199	109	70	58	—	—	—	—	434	2	51	—
Maine												
Univ. Maine	295	177	138	126	9	—	7	—	742	10	118	—
Maryland												
Johns Hopkins	123	138	123	123	—	—	—	362	869	—	110	—
Md. Univ	521	167	130	109	—	—	15	—	936	6	135	—
Massachusetts												
Harvard	—	60	24	30	—	—	—	—	114	—	14	—
Lowell Textile	115	49	47	50	—	—	—	—	261	—	41	—
Mass. Inst. Tech	635	704	555	592	—	—	—	—	2,462	24	546	—
Mass. Univ	291	192	88	60	—	—	—	—	623	8	50	—
Northeastern	725	488	300	298	—	285	—	—	2,087	9	327	1
Tufts	205	136	108	98	—	—	—	—	540	7	104	—
Worcester	264	172	151	124	—	—	—	—	711	—	141	—
Michigan												
Detroit Univ	586	261	174	173	—	252	—	27	1,469	4	219	—
Mich. M. & T	470	302	221	188	—	—	5	—	1,180	6	205	—
Mich. St. Coll	565	368	317	299	—	—	—	—	1,549	—	216	—
Mich. Univ	565	645	341	368	—	—	54	—	1,956	17	399	1
Wayne Univ	428	238	219	206	—	—	54	—	1,125	20	125	—

Minnesota												
Univ. Minn.	674	424	383	271	265	—	41	—	2,050	8	272	—
Mississippi												
Miss. St. Coll.	277	188	134	102	—	—	—	—	699	2	70	—
Miss. Univ.	74	51	36	19	—	—	—	—	176	4	30	—
Missouri												
Mo. Mines	420	213	251	240	—	—	—	48	1,168	4	225	—
Mo. Univ.	422	219	127	85	—	—	—	—	850	3	108	—
St. Louis Univ.	195	115	56	84	—	—	3	7	458	2	71	—
Wash. Univ. (St. L.)	265	207	139	132	—	—	—	—	741	2	128	—
Montana												
Mont. St. Coll.	245	151	64	87	—	—	—	—	547	—	86	—
Mont. Mines	93	72	45	45	—	—	—	—	255	—	42	—
Nebraska												
Nebr. Univ.	372	193	130	117	—	—	12	—	822	2	108	—
Nevada												
Nevada Univ.	78	46	38	25	—	—	—	—	187	—	28	—
New Hampshire												
Dartmouth	120	95	28	31	—	—	—	—	274	—	14	—
New Hamp. Univ.	190	132	75	68	—	—	—	—	462	3	70	—
New Jersey												
Newark	400	321	217	162	—	—	—	1,147	2,221	26	257	1
Princeton	151	154	132	96	—	—	—	—	533	—	98	—
Rutgers	204	127	89	55	—	—	4	—	474	5	58	—
Stevens	308	222	139	127	—	—	—	—	796	—	186	—
New Mexico												
N. Mex. A. & M.	200	109	61	59	—	—	7	146	578	4	42	—
N. Mex. Univ.	255	102	87	89	—	—	—	29	559	3	88	—
New York												
Alfred	66	58	32	37	—	—	4	—	193	4	27	—
Brooklyn Poly.	364	465	273	223	—	—	—	1,862	3,185	2	407	—
Clarkson	313	184	157	124	—	—	—	—	778	—	149	—
City Coll. of N. Y.	1,549	760	439	420	—	—	—	997	4,130	35	311	2
Columbia	—	—	127	105	—	—	—	—	229	3	100	2
Cooper Union	111	84	79	70	—	—	—	355	690	9	106	—
Cornell	550	354	246	257	252	—	2	—	1,647	14	241	—
Manhattan	287	248	213	117	—	—	—	—	865	—	112	—
N. Y. Univ.	344	322	252	230	—	—	3	1,136	2,276	11	358	—
Pratt	88	59	37	36	—	—	1	—	219	2	39	—
Rensselaer	736	508	435	453	—	—	4	168	2,304	—	497	—
Rochester	71	63	42	30	1	—	—	—	207	—	34	—
Syracuse	194	131	111	88	—	—	26	—	549	1	122	—
Union Coll.	129	87	37	32	—	—	—	—	285	—	42	—
Webb	20	12	17	14	—	—	—	—	63	—	14	—
North Carolina												
Duke Univ.	182	134	77	79	—	—	2	—	474	—	57	—
N. C. St. Coll.	837	489	236	273	9	—	—	—	1,842	2	267	1

Total Undergraduate Engineering Enrollment, by School, October 5, 1953—*Continued*

Institutions	Total Number Enrolled for Their First Engineering Degree										Number of First Engineering Degrees Conferred 1952–53	
	1st yr.	2nd yr.	3rd yr.	4th yr.	5th yr. of 5-yr. Curriculum	5th yr. of Cooperative Program	Part-Time and Special Day Students	Evening Students	Total			
									Men	Women	Men	Women
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
North Dakota												
N. Dak. Ag. Coll.	213	150	97	94	2	—	—	—	555	1	70	—
N. Dak. Univ.	177	122	65	65	—	—	2	—	431	—	50	—
Ohio												
Akron	171	68	39	23	—	39	—	41	378	3	39	—
Case Inst.	348	252	206	214	—	—	14	166	1,198	2	219	—
Cincinnati	400	288	182	204	—	202	—	—	1,269	7	230	—
Fenn	143	70	61	45	—	76	1	722	1,113	5	136	—
Ohio St. Univ.	862	482	311	238	268	—	27	316	2,494	10	271	—
Ohio Univ.	272	143	83	87	—	—	—	—	583	2	63	—
Toledo	252	142	101	85	—	—	—	600	1,180	—	90	—
Univ. Dayton	251	74	37	32	—	—	18	134	544	2	38	—
Oklahoma												
Okla. A. & M.	500	323	227	247	17	6	2	—	1,318	4	169	—
Okla. Univ.	676	474	322	373	—	—	—	—	1,831	14	254	4
Tulsa	221	111	106	104	—	—	12	194	732	16	102	—
Oregon												
Oregon State	378	222	147	175	—	—	243	—	1,163	2	155	—
Pennsylvania												
Bucknell	112	69	46	44	—	—	—	—	268	3	55	1
Carnegie	336	305	222	237	—	—	2	649	1,744	7	247	—
Drexel	476	417	225	172	—	156	10	—	1,446	10	200	—
Lafayette	264	168	104	81	—	—	—	—	617	—	123	—
Lehigh	602	401	298	249	—	—	—	—	1,550	—	269	—
Pa. St. Coll.	1,143	713	547	446	20	—	17	—	2,842	44	454	1
Pittsburgh	379	287	232	215	—	—	120	439	1,669	3	250	—
Swarthmore	34	28	21	15	—	—	—	—	98	—	17	—
Univ. Pa.	148	107	60	65	1	—	—	—	381	—	85	—
Villanova	280	173	84	63	14	—	—	13	627	—	79	—
Rhode Island												
Brown	115	75	36	46	—	—	—	—	271	1	25	1
R. I. Univ.	175	102	83	65	—	—	—	—	423	2	74	—
South Carolina												
Citadel	160	115	63	53	—	—	—	—	391	—	49	—
Clemson	546	291	181	156	—	—	—	—	1,174	—	169	—
S. C. Univ.	250	117	78	67	—	—	—	—	511	1	52	1

South Dakota												
S. Dak. Mines	222	108	70	61	—	—	—	—	461	—	77	—
S. Dak. St. Coll.	224	98	40	27	—	—	—	—	388	1	43	1
Tennessee												
Tenn. Univ.	430	321	194	146	—	—	—	—	1,088	3	117	—
Vanderbilt	149	129	106	84	—	—	5	—	470	3	65	—
Texas												
A. & M. Coll. Texas	1,012	551	462	453	79	—	20	—	2,577	—	500	—
Rice	—	—	67	68	55	—	—	—	190	—	55	—
Southern Meth.	149	84	45	55	—	46	3	—	381	1	69	—
Tex. Coll. A. & I.	130	100	45	22	—	—	—	—	297	—	22	—
Tex. Tech. Coll.	502	258	178	196	—	—	—	—	1,128	6	141	—
Tex. Western	164	61	41	61	—	—	—	128	452	3	8	—
Tex. Univ.	714	558	440	374	—	—	—	—	2,082	4	296	4
Univ. Houston	704	291	292	359	4	—	12	—	1,653	9	140	—
Utah												
Utah Ag. Coll.	127	98	61	57	—	—	—	—	342	1	58	—
Utah Univ.[1]	512	172	175	201	—	—	11	—	1,071	—	95	—
Vermont												
Norwich	114	56	58	30	—	—	1	—	259	—	22	—
Vermont Univ.	111	77	44	37	—	—	5	—	274	—	40	—
Virginia												
Va. Mil. Inst.	160	106	121	68	—	—	—	—	455	—	78	—
Va. Poly.	931	343	189	294	—	—	28	—	1,784	1	281	—
Va. Univ.	214	164	81	64	—	—	1	—	524	—	50	—
Washington												
Wash. St. Coll.	268	217	124	110	19	—	—	—	730	8	101	—
Wash. Univ.	655	279	282	265	—	11	—	—	1,486	6	261	—
West Virginia												
W. Va. Univ.	263	217	117	94	—	—	—	2	688	5	104	—
Wisconsin												
Marquette	385	246	173	158	—	—	—	283	1,242	3	143	—
Univ. Wisc.	1,036	510	325	289	—	—	—	—	2,155	5	324	—
Wyoming												
Wyoming Univ.	176	115	98	63	—	—	—	—	450	2	67	—
Dist. of Columbia												
Catholic Univ.	55	67	47	58	—	—	21	—	248	—	72	—
Geo. Wash. Univ.	71	28	27	24	—	—	296	—	443	3	60	—
Howard Univ.	133	33	26	30	—	—	1	—	222	1	26	—
Alaska												
Univ. Alaska	44	13	18	8	1	—	—	—	82	2	10	—
Hawaii												
Univ. Hawaii	120	89	64	51	—	—	2	—	324	2	46	—
Total ECPD Schools	52,482	32,953	23,975	21,730	1,121	1,275	1,673	15,217	149,659	767	21,612	30

[1] Estimated.

Total Graduate Engineering Enrollmen[illegible]l, October 5, 1953

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1952–53		Number Enrolle for Other Post- Pre-Doctoral		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1952–53	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Student	Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.					Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited schools:														
Alabama														
Ala. Poly	16	—	16	—	4	—	—	—	—	—	—	—	—	—
Univ. Ala	16	—	16	—	4	—	—	—	—	—	—	—	—	—
Arizona														
Univ. Ariz	32	70	99	3	7	—	—	—	9	—	9	—	—	—
Arkansas														
Univ. Ark	17	18	35	—	7	—	—	—	—	—	—	—	—	—
California														
Calif. Tech	75	—	75	—	60	—	43	—	51	—	51	—	22	—
Stanford	223	—	223	—	113	—	27	—	52	—	52	—	24	—
Univ. Calif. (B.)	158	—	155	3	80	—	—	—	68	—	68	—	5	—
Univ. Calif. (L. A.)	214	—	214	—	16	—	—	—	45	—	44	1	3	—
Univ. Southern Calif	238	—	235	3	55	—	20	—	8	—	8	—	—	—
U. S. Naval PG Sch.[2]	74	—	74	—	29	—	—	—	—	—	—	—	—	—
Colorado														
Colo. A. & M	21	—	21	—	5	—	—	—	3	—	3	—	—	—
Colo. Mines	42	—	42	—	16	—	—	—	21	—	21	—	7	—
Univ. Denver	3	—	3	—	6	—	—	—	—	—	—	—	—	—
Univ. Colo	42	94	136	—	20	—	—	—	—	—	—	—	2	—
Connecticut														
Univ. Conn	15	155	170	—	13	—	—	—	—	—	—	—	—	—
Yale Univ	59	—	58	1	29	—	—	—	57	—	57	—	5	—
Delaware														
Univ. Delaware	18	225	242	1	24	—	—	—	20	—	20	—	6	—
Florida														
Univ. Florida	34	—	33	1	21	—	—	—	10	—	10	—	—	—

MISNUM

Georgia														
Ga. Tech	167	—	167	—	57	—	—	—	22	—	22	—	9	—
Idaho														
Univ. Idaho	9	—	9	—	9	—	—	—	—	—	—	—	—	—
Illinois														
Bradley	—	2	2	—	4	—	—	—	—	—	—	—	—	—
Ill. Inst. Tech	61	398	458	1	64	1	—	—	28	104	130	2	15	—
Northwestern	46	89	135	—	15	—	—	2	30	10	40	—	16	—
Univ. Ill	286	—	280	6	157	—	—	—	229	—	227	2	31	—
Indiana														
Notre Dame	23	25	48	—	15	—	—	—	54	—	54	—	2	—
Purdue	229	—	229	—	122	—	3	—	93	—	93	—	33	—
Rose Poly	3	—	3	—	1	—	—	—	—	—	—	—	—	—
Iowa														
Iowa St. Coll	68	—	68	—	26	—	—	—	48	—	48	—	7	—
St. Univ. Iowa	46	—	46	—	34	2	—	—	22	—	22	—	10	—
Kansas														
Kan. St. Coll	22	—	22	—	13	—	—	—	2	—	2	—	—	—
Kan. Univ	23	64	87	—	11	—	—	—	6	—	6	—	1	—
Wichita	—	19	19	—	2	—	—	—	—	—	—	—	—	—
Kentucky														
Ky. Univ	32	—	32	—	10	—	—	—	2	—	2	—	1	—
Louisville	9	51	60	—	12	—	—	—	—	—	—	—	—	—
Louisiana														
Louisiana St. Univ	28	—	28	—	20	—	—	—	2	—	2	—	1	—
Tulane Univ	15	—	15	—	5	—	—	—	—	—	—	—	—	—
Maine														
Univ. Maine	9	—	9	—	4	—	—	—	—	—	—	—	—	—
Maryland														
Johns Hopkins	93	64	157	—	29	—	—	—	67	—	66	1	7	—
Md. Univ	367	10	376	1	24	—	—	—	21	1	22	—	2	—
Massachusetts														
Harvard	87	12	99	—	66	—	1	—	55	—	54	1	12	—
Lowell Textile	5	—	5	—	4	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech	684	—	682	2	375	1	147	—	290	—	287	3	87	—
Mass. Univ	4	17	21	—	2	—	—	—	—	—	—	—	—	—
Northeastern	—	731	721	10	21	—	—	—	—	—	—	—	—	—
Tufts	—	4	4	—	—	—	—	—	—	—	—	—	—	—
Worcester	18	—	18	—	6	—	—	—	—	—	—	—	—	—
Michigan														
Mich. M. & T	14	—	14	—	8	—	2	—	—	—	—	—	—	—
Mich. St. Coll	46	—	46	—	25	—	—	—	12	—	12	—	8	—
Mich. Univ	319	—	317	2	145	—	2	—	138	—	138	—	34	—
Wayne Univ	204	—	203	1	14	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 5, 1953

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1952–53		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1952–53		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1952–53	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
ECPD accredited schools:																		
Alabama																		
Ala. Poly.	16	—	16	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Ala.	16	—	16	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Arizona																		
Univ. Ariz.	32	70	99	3	7	—	—	—	—	—	—	—	9	—	9	—	—	—
Arkansas																		
Univ. Ark.	17	18	35	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
California																		
Calif. Tech.	75	—	75	—	60	—	43	—	43	—	18	—	51	—	51	—	22	—
Stanford	223	—	223	—	113	—	27	—	27	—	12	—	52	—	52	—	24	—
Univ. Calif. (B.)	158	—	155	3	80	—	—	—	—	—	10	—	68	—	68	—	5	—
Univ. Calif. (L. A.)	214	—	214	—	16	—	—	—	—	—	—	—	45	—	44	1	3	—
Univ. Southern Calif.	238	—	235	3	55	—	20	—	20	—	—	—	8	—	8	—	—	—
U. S. Naval PG Sch.[2]	74	—	74	—	29	—	—	—	—	—	—	—	—	—	—	—	—	—
Colorado																		
Colo. A. & M.	21	—	21	—	5	—	—	—	—	—	—	—	3	—	3	—	—	—
Colo. Mines	42	—	42	—	16	—	—	—	—	—	—	—	21	—	21	—	7	—
Univ. Denver	3	—	3	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Univ. Colo.	42	94	136	—	20	—	—	—	—	—	2	—	—	—	—	—	2	—
Connecticut																		
Univ. Conn.	15	155	170	—	13	—	—	—	—	—	—	—	—	—	—	—	—	—
Yale Univ.	59	—	58	1	29	—	—	—	—	—	—	—	57	—	57	—	5	—
Delaware																		
Univ. Delaware	18	225	242	1	24	—	—	—	—	—	—	—	20	—	20	—	6	—
Florida																		
Univ. Florida	34	—	33	1	21	—	—	—	—	—	—	—	10	—	10	—	—	—

Georgia																		
Ga. Tech	167	—	167	—	57	—	—	—	—	—	—	—	22	—	22	—	9	—
Idaho																		
Univ. Idaho	9	—	9	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Illinois																		
Bradley	—	2	2	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Ill. Inst. Tech	61	398	458	1	64	1	—	—	—	—	—	—	28	104	130	2	15	—
Northwestern	46	89	135	—	15	—	—	2	2	—	—	—	30	10	40	—	16	—
Univ. Ill	286	—	280	6	157	—	—	—	—	—	—	—	229	—	227	2	31	—
Indiana																		
Notre Dame	23	25	48	—	15	—	—	—	—	—	—	—	54	—	54	—	2	—
Purdue	229	—	229	—	122	—	3	—	3	—	—	—	93	—	93	—	33	—
Rose Poly	3	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Iowa																		
Iowa St. Coll	68	—	68	—	26	—	—	—	—	—	—	—	48	—	48	—	7	—
St. Univ. Iowa	46	—	46	—	34	2	—	—	—	—	—	—	22	—	22	—	10	—
Kansas																		
Kan. St. Coll	22	—	22	—	13	—	—	—	—	—	—	—	2	—	2	—	—	—
Kan. Univ	23	64	87	—	11	—	—	—	—	—	—	—	6	—	6	—	1	—
Wichita	—	19	19	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Kentucky																		
Ky. Univ	32	—	32	—	10	—	—	—	—	—	—	—	2	—	2	—	1	—
Louisville	9	51	60	—	12	—	—	—	—	—	—	—	—	—	—	—	—	—
Louisiana																		
Louisiana St. Univ	28	—	28	—	20	—	—	—	—	—	—	—	2	—	2	—	1	—
Tulane Univ	15	—	15	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Maine																		
Univ. Maine	9	—	9	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Maryland																		
Johns Hopkins	93	64	157	—	29	—	—	—	—	—	—	—	67	—	66	1	7	—
Md. Univ	367	10	376	1	24	—	—	—	—	—	—	—	21	1	22	—	2	—
Massachusetts																		
Harvard	87	12	99	—	66	—	1	—	1	—	3	—	55	—	54	1	12	—
Lowell Textile	5	—	5	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Mass. Inst. Tech	684	—	682	2	375	1	147	—	147	—	42	—	290	—	287	3	87	—
Mass. Univ	4	17	21	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Northeastern	—	731	721	10	21	—	—	—	—	—	—	—	—	—	—	—	—	—
Tufts	—	4	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worcester	18	—	18	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Michigan																		
Mich. M. & T	14	—	14	—	8	—	2	—	2	—	7	—	—	—	—	—	—	—
Mich. St. Coll	46	—	46	—	25	—	—	—	—	—	—	—	12	—	12	—	8	—
Mich. Univ	319	—	317	2	145	—	2	—	2	—	2	—	138	—	138	—	34	—
Wayne Univ	204	—	203	1	14	—	—	—	—	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 5, 1953—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1952–53		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1952–53		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1952–53	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Minnesota																		
Univ. Minn.	170	46	215	1	55	—	—	4	4	—	2	—	107	—	107	—	10	—
Mississippi																		
Miss. St. Coll.	2	—	2	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Miss. Univ.	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Missouri																		
Mo. Mines	37	—	37	—	11	—	—	—	—	—	—	—	12	—	12	—	1	—
Mo. Univ.	23	—	23	—	16	—	—	—	—	—	—	—	1	—	1	—	3	—
St. Louis Univ.	25	131	156	—	14	—	—	—	—	—	—	—	4	—	4	—	3	—
Wash. Univ. (St. L.)	147	—	147	—	16	—	—	—	—	—	—	—	36	—	35	1	6	—
Montana																		
Mont. St. Coll.	16	—	16	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Mont. Mines	8	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nebraska																		
Nebr. Univ.	9	—	9	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
Nevada																		
Univ. Nevada	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire																		
Dartmouth	37	—	37	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—
New Hampshire Univ.	3	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
New Jersey																		
Newark	—	685	680	5	99	—	—	—	—	—	—	—	—	—	—	—	—	—
Princeton	80	4	84	—	25	—	—	—	—	—	—	—	34	—	34	—	6	—
Rutgers	127	—	125	2	18	—	—	—	—	—	—	—	—	—	—	—	—	—
Stevens	—	953	938	15	149	2	—	—	—	—	—	—	—	10	10	—	—	—
New Mexico																		
N. Mex. A. & M.	3	30	33	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N. Mex. Univ.	12	117	129	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—
New York																		
Alfred	8	—	8	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Brooklyn Poly.	53	1,390	1,439	4	121	—	—	—	—	—	—	—	11	164	175	—	15	—
Clarkson	7	—	7	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
City Coll. of N. Y.	—	330	330	—	28	—	—	—	—	—	—	—	—	—	—	—	—	—

Columbia	404	485	886	3	106	2	2	—	2	—	—	—	13	89	101	1	6	—
Cornell	80	—	80	—	37	1	—	—	—	—	—	—	67	—	66	1	19	—
N. Y. Univ.	—	759	759	—	155	6	—	—	—	—	—	—	—	172	172	—	3	—
Rensselaer	106	38	144	—	63	—	—	—	—	—	—	—	38	11	49	—	6	—
Rochester	40	2	42	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Syracuse	27	429	456	—	13	—	—	—	—	—	—	—	18	6	24	—	2	—
Union Coll.	—	57	57	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Webb	12	—	12	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—
North Carolina																		
N. C. St. Coll.	75	17	92	—	46	—	—	—	—	—	—	—	12	—	12	—	1	—
North Dakota																		
N. D. Univ.	9	—	9	—	2	—	—	—	—	—	—	—	1	—	1	—	—	—
Ohio																		
Case Inst.	78	277	351	4	72	—	—	—	—	—	—	—	26	36	61	1	12	—
Cincinnati	16	182	198	—	5	—	—	—	—	—	—	—	7	—	7	—	5	—
Ohio St. Univ.	203	116	319	—	86	—	—	—	—	—	—	—	101	20	121	—	32	—
Oklahoma																		
Oklahoma A. & M.	93	1	94	—	40	—	—	—	—	—	—	—	12	—	12	—	2	—
Okla. Univ.	50	—	50	—	17	—	—	—	—	—	—	—	3	—	3	—	—	—
Tulsa	26	—	15	11	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oregon																		
Oregon State	21	—	21	—	8	—	4	—	4	—	—	—	2	—	2	—	—	—
Pennsylvania																		
Bucknell	3	—	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
Carnegie	49	71	120	—	59	—	—	—	—	—	—	—	64	—	64	—	21	—
Drexel	261	—	261	—	24	—	—	—	—	—	—	—	—	—	—	—	—	—
Lehigh	61	—	61	—	8	—	—	—	—	—	—	—	18	—	18	—	5	—
Pa. State Coll.	213	—	209	4	54	—	—	—	—	—	5	—	—	—	—	—	15	—
Pittsburgh	31	482	513	—	58	—	—	—	—	—	—	—	10	72	82	—	3	—
Univ. Pa.	102	616	718	—	49	—	—	—	—	—	—	—	59	1	60	—	5	4
Villanova	—	94	94	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Rhode Island																		
Brown	20	—	20	—	4	—	—	—	—	—	—	—	4	—	4	—	1	—
R. I. Univ.	6	5	10	1	4	—	—	—	—	—	—	—	—	—	—	—	—	—
South Carolina																		
Clemson	14	—	14	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—
South Dakota																		
S. Dak. Mines	9	—	9	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Dak. St. Coll.	3	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Tennessee																		
Tenn. Univ.	93	—	93	—	18	—	25	—	25	—	—	—	9	—	9	—	2	—
Vanderbilt	4	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Total Graduate Engineering Enrollment, by School, October 5, 1953—*Continued*

Institutions	Number Enrolled in Work for the Master's Degree				No. of Master's Degrees Conferred in Eng'g 1952–53		Number Enrolled in Work for Other Post-Graduate Pre-Doctoral Degrees[1]				No. of Post-Grad. Degrees[1] Conferred in Eng'g 1952–53		Number Enrolled in Work for the Doctor's Degree				No. of Doctor's Degrees Conferred in Eng'g 1952–53	
	Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total				Day Students Full Time and Part Time	Evening and Special Students	Total			
			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.			Men	Wo.	Men	Wo.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Texas																		
A. & M. Coll. Tex.	65	—	65	—	34	—	—	—	—	—	2	—	13	—	13	—	7	—
Rice	10	—	10	—	6	—	—	—	—	—	—	—	—	—	—	—	—	—
Southern Meth.	3	342	342	3	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Coll. A. & I.	3	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Tech. Coll.	5	—	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tex. Univ.	104	—	103	1	—	—	—	—	—	—	—	—	36	—	36	—	10	—
Univ. Houston	173	—	173	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—
Utah																		
Utah Ag. Coll.	15	—	15	—	3	—	—	—	—	—	1	—	1	—	1	—	1	—
Utah Univ.[2]	34	25	59	—	6	—	—	—	—	—	2	—	11	—	11	—	—	—
Virginia																		
Va. Poly.	49	—	49	—	29	—	—	—	—	—	—	—	8	—	8	—	3	—
Va. Univ.	17	256	273	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—
Washington																		
Wash. St. Coll.	10	—	10	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Wash. Univ.	123	48	166	5	51	—	—	—	—	—	—	—	15	—	15	—	3	—
West Virginia																		
W. Va. Univ.	28	—	28	—	9	—	—	—	—	—	—	—	9	—	9	—	5	—
Wisconsin																		
Univ. Wisconsin	60	211	271	—	67	—	2	—	2	—	—	—	71	—	71	—	24	—
Wyoming																		
Univ. Wyoming	9	—	9	—	7	—	—	—	—	—	—	—	—	—	—	—	—	—
District of Columbia																		
Catholic Univ.	4	54	58	—	12	—	—	—	—	—	—	—	—	7	7	—	—	—
Geo. Wash. Univ.	—	14	14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total ECPD Schools	7,806	10,315	18,025	96	3,603	15	278	6	284	—	108	—	2,298	703	2,987	14	588	4

[1] Other engineering degrees requiring work beyond the Master's degree, but less than the requirements for a Doctor's degree.
[2] Estimated.

Do You Know—

► A grant of $10,000 has been received from the General Electric Company to assist the ASEE in the completion of the project Evaluation of Engineering Education. The Committee met in Atlanta, Georgia, February 18–20 to start preparation of the final report, based upon recommendations from some 118 institutional committees which have worked with the Society Committee in this undertaking. It is expected that the Committee will meet once more in order to complete its work prior to the Annual Meeting in June.

► The National Science Foundation has authorized grants totaling $15,700 for the ASEE sponsored Summer Institutes. The purpose of the Summer Institute program is to expedite the introduction into engineering education of new fundamental concepts in rapidly developing fields of science and technology which hold great promise for the future of engineering. These Summer Institutes will clarify fundamental concepts, assess material as to its importance in engineering education, and seek a logical, orderly pattern for teaching purposes. Each Summer Institute symposium will be preceded by a work conference of leading authorities in the field, representing the divergent viewpoints of the research engineer, the scientist and the educator.

Two Summer Institutes will be held during the Summer of 1954. One will be in the broad field of Solid State Physics and the other in Nuclear Science. The working panel on the Solid State Physics Conference will meet at the University of Illinois, and the open conference will be held at Carnegie Institute, June 21–25, 1954. The working panel for the Nuclear Physics Conference will be at Columbia University and the open conference will be held at Northwestern University, September 7–11, 1954. Please note that advance registration is required at both of the open conferences. Attendance will be limited to 100 people. Announcement of these Summer Institutes appears elsewhere in this issue of the Journal.

► The Society will sponsor six Summer Schools this year, the largest number in its history. Most of these will be held either prior to or immediately after the Annual Meeting at the University of Illinois. An announcement of the Summer Schools and who to write to for information can be found elsewhere in this issue of the Journal. If you plan to attend, please apply early since the attendance at some of these Summer Schools will be limited.

► The Fifth Annual College-Industry Conference, sponsored by the ASEE Division of Relations With Industry, was held in Detroit, January 15–16, in cooperation with the Engineering Society of Detroit and a number of Michigan colleges. Over 350 industrial leaders and educators heard an interesting exposition of the ECPD's program "The First Five Years of Professional Development." This program, which is in the pilot stage at Cincinnati under the direction of Professor Wandmacher, is working with industry and engineering colleges in developing educational programs for the young engineering graduate after he gets into industry. Engineering graduates, embarking upon a new career, after experiencing the unlimited horizons of a

college education, often find the conventionality and the restraining influences of industry severe deterrents to their ambitions and hopes. At this stage in life, the continuing educational programs can serve to bolster the individual's professional growth and improve his outlook on life.

Many thanks to John Gammell, Dean Freund, Don Hunt, and others at the University of Detroit, as well as Guile Graham of the Engineering Society of Detroit for the excellent job in planning and staging this conference.

► May we call your attention to the proposed amendment to By-Law IV on dues of members, printed in this issue of the *Journal*. Ballots will be mailed to the Society membership toward the end of April.

► A technicality in the regulations relating to discharge of draftees from military service might prove helpful to engineering colleges which are considering hiring draftees for teaching or research. If the individual can show a contract for his services, he can get a discharge three months early (after 17 months of service).

► The new President of EJC is our ASEE representative, Dean Thorndike Saville. The Secretary of ASEE will serve as EJC's Chairman of the Committee on Society Secretaries.

► The Annual Meeting this year is shaping up to be one of the most outstanding events in the history of ASEE. One of the General Sessions will be devoted largely to a panel report on Evaluation of Engineering Education, followed by discussion from the floor.

► The ECRC is programing an interesting General Session dealing with "Portraits in Creativity." This will include 3 or 4 leading scientists and engineers who have made substantial contributions in creative thought. They will discuss some of the insights into creative thought processes. Engineering colleges for the most part have emphasized analytical type of thinking. We know very little about what is involved in creative thinking or why some individuals have exceptional creative abilities, while others are completely lacking in this trait.

► The ECAC is preparing an interesting General Session dealing with "Recognition and Incentives for Good Teaching," in cooperation with the Committee on Recognition and Incentives for Good Teaching, the Educational Methods Division, and the Young Engineering Teachers Committee of the Society.

► On Monday afternoon, a session of interest to all Society members will deal with reports on major Society projects. This will include brief reports and discussions on Ethics, the Summer Institute program, the new Humanistic-Social Research Project, Engineering Manpower, Technical Institutes, Teaching Salaries, and other important committee projects.

► In previous issues, we have been giving you snapshot glimpses of a few of the outstanding items in the Annual Meeting program. Here are more which came in as this issue was going off to press.

► The Educational Methods Division and Graduate Studies Division are pooling forces in a conference dealing with the "Integration of Graduate and Undergraduate Instruction" and also another phase of this problem, "Graduate Studies for Engineering Teachers." The Educational Methods Division will also have a conference on "Educational Research and Evaluation of Teaching." The Educational Methods Division and the Mechanical Engineering Division are combining in a program dealing with "Integrating the Science and Art of Engineering and Creative Design."

► Mechanical Engineering has an intriguing paper by Dean Tupper of Toronto entitled "The Masses, Classes, and

Education." They also have a conference with papers on Ethical Relations Between Students and Instructors as well as What the College Expects of the Young Instructor.

▶ The ECRC and Relations with Industry Division are holding a Joint Conference dealing with "Industrial Sponsorship of Research," looking forward to expanding industrial research as a means of counteracting the decline in government research.

▶ From Engineering Drawing comes the interesting information of programs dealing with "Fundamentals, What Are They?," "Graphics in an Expanding Scientific Age," and "Analytic Graphics and Engineering Problem Solving," and a dinner talk on "The Past and the Future" by Professor Northrup.

▶ Chemical Engineering promises an interesting discussion program on "Chemical Engineering Economics" as well as another on "Improvement of Educational Standards in Secondary Schools."

▶ A number of Divisions are meeting with the Physics Division on Tuesday afternoon to thrash out the subject of "Physics in Engineering Education." This will include the introduction of modern Physics at appropriate places in the advanced engineering curriculum and the problems of establishing a more satisfactory integration of Physics and engineering at the Sophomore level.

▶ The Electrical Engineering Division has a conference on "The Problems of Training in the Use of Computing Equipment" and a Summer School on "The Elements of Design of Digital Control Circuits," featuring a team of experts from the Bell Telephone Laboratory. The Electrical Engineering Division also plans to hold several conferences on "The Professional Scientific and Professional General Curricula in Power and Electronics."

▶ The Mathematics Division will hold conferences on "The Problems of Training in the Use of Computing Equipment," "Mathematics as a Sister Science," "The Teaching of Mathematics in Engineering Schools," "The Place of Mathematical Statistics in the Engineering Curriculum."

▶ The foregoing is a synopsis of a few of about 100 conference titles. In each of these conferences there are many interesting papers which you will want to hear. We will send you a Preliminary Program of the Annual Meeting and registration forms about the end of April. You will want to mark your calender now to attend the Annual Meeting at the University of Illinois, June 14–18.

▶ We have a number of other lively projects coming to the forefront which we will tell you about in the April and May issues of the *Journal*. Watch this column.

▶ We'll see you at the Annual Meeting.

ARTHUR BRONWELL, *Secretary*

Annual Meeting, University of Illinois
June 14-18, 1954

An expansive view over Illinois plains will herald for ASEE members the nearness of the host institution for this year's Annual Meeting. Coming closer into the north-central part of the state, towering elm trees are the distinguishing mark of the twin cities of Urbana and Champaign in which is located the main campus of the University of Illinois.

Founded in 1868 as one of a group of colleges partially supported by the Federal Government under the "Land-Grant College Act," the University of Illinois began its history with three faculty members and fifty students. Today on its three campuses, it has a total enrollment of more than 23,000 and a teaching staff of 3,000.

The center of its program, and its administrative offices, are on the main campus at Urbana. Here are fourteen colleges and schools offering 3,000 different courses to nearly 16,000 students. On this campus, the University of Illinois probably has more full-time students in residence than any other educational institution in the country.

The University's Undergraduate Division in Chicago is located on Navy Pier. This Division offers the first two years of college work analagous to that given on the main campus in engineering and architecture, in liberal arts and sciences, and in commerce and business administration. The engineering staff at Navy Pier will join those at Urbana in serving as hosts during the Annual Meeting.

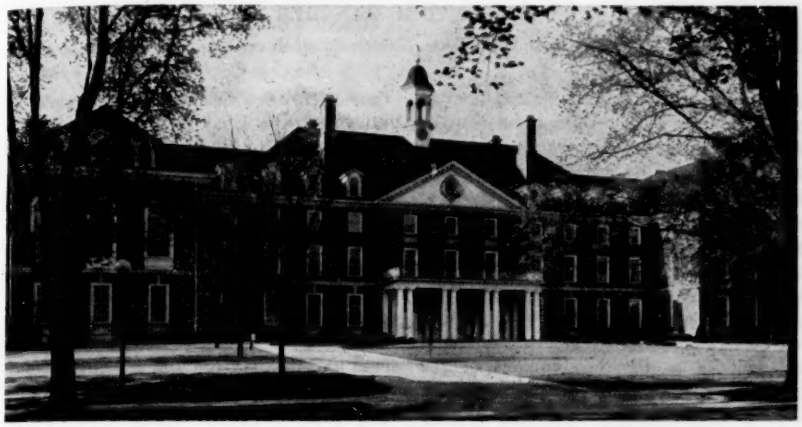
Chicago is also the home of the University's professional units which include the Colleges of Medicine, Dentistry and Pharmacy, and the School of Nursing.

Frequently known as the "front door" of the campus for visitors and the "community center" for students and staff, the Illini Union Building will likewise be the center and main headquarters for the meeting of the ASEE June 13–19. This spacious colonial-style building includes lounges, reading rooms, dining rooms, cafeteria, game rooms and ballroom. Guests may be interested, as well, in many of the approximately ninety-four structures comprising the Urbana-Champaign campus. However, second to the Illini Union, the most prominent building for ASEE members will probably be Gregory Hall. Since, like the Union, Gregory Hall is equipped with air conditioning, most of the main meeting rooms will be located in this building, which regularly houses the Colleges of Education and Journalism. The newest residence hall for women at the University of Illinois, Lincoln Avenue Residence, will be assigned to the ASEE and will provide housing for many of its members, particularly those who bring their families.

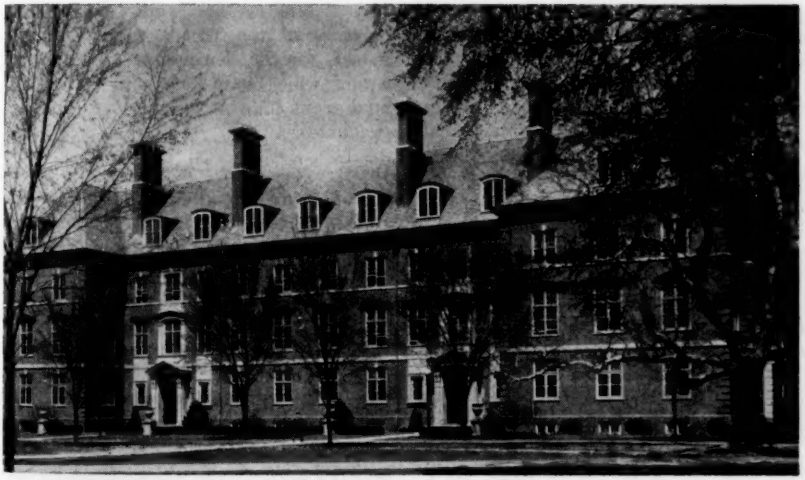
Most of those attending the meeting will have an opportunity to visit Robert Allerton Park, twenty-six miles southwest of Urbana-Champaign. The mansion house is complemented by formal and informal gardens, statuary and over a thousand acres of rich woodland, which serve as a public park. Allerton House is used regularly as a conference center for the University.

Coming or going to the Annual Meeting, tourist-inclined members may be interested in the Lincoln shrines around Springfield and New Salem—west of Urbana—or in Chicago and the Great

Lakes region northward. As one nears St. Louis on the west, or as one approaches the lake country of Wisconsin and Minnesota on the north, one finds rolling terrain in strong contrast to the Illinois plains. The latter, nevertheless, provide an experience in themselves, and without a doubt have in store a welcome for those attending the Annual Meeting of 1954.



Illini Union Building, University of Illinois, Urbana-Champaign



Gregory Hall, University of Illinois, Urbana-Champaign

Liberal Education in Professional Curricula*

By VIRGIL M. HANCHER
President, State University of Iowa

When your President invited me to speak on some aspect of the relation of liberal education to professional education, it occurred to me that one aspect of that relationship which has received very little consideration or discussion, as far as I can determine, is the use of the subject matter of professional curricula as a basis for liberal education.

No doubt we can start off by agreeing that some elements of a liberal education are essential to the development of the good citizen, and that the possession of those elements of liberal education by their graduates should be the goal of our state universities and of our land-grant colleges.

Having said this, however, we are sometimes at a loss to describe those elements in more precise language. What we mean is easier to recognize than to define. One of my distinguished predecessors at the State University of Iowa has said that a liberal education is more quickly recognized by its absence than by its presence. We implicitly sense the comprehensiveness and breadth of knowledge, the understanding and the insight which mark the liberally educated man. We recognize and value the tolerance, urbanity and breadth of spirit which come with a basic and fundamental knowledge of man, his society and institutions, their development out of the long past, and their place in the dynamic present.

We expect to find in the liberally educated man, therefore, the ability to ascertain facts and to act upon them; to know the society of which he is a part, and how it came to be what it is; and to possess the imagination and insights necessary to see the direction in which society is moving. We expect him to be able to make wise choices, both for the guidance of his personal life and for the collective decisions of the society of which he is a part. We expect him to know that knowledge is power and, even more significantly, that knowledge is freedom—freedom from disease and pestilence, from superstition and taboo, and from the fears and terrors that possess the mind and touch the soul of uncivilized man. We expect him to know that this knowledge, combined with vision and creative power, can harness the forces of nature and work for the establishment of the "good" society. These, indeed, are the elements of a liberal education which our state universities and land-grant colleges seek to instill in their graduates.

Two Obstacles

But there are two considerable obstacles to the achievement of this goal; time and money.

We must always be concerned with the time required in the educational process. Are we doing all that we should in the time allotted? Could we do as much work of equal quality in less time? These are questions we must always keep before us. Our curricular patterns must be selective and basic. We must decide between those things which can be learned best and most economically in college and those which can be learned best and most economically outside. The demands on the time of youth are becoming very great

* Presented at Association of Land-Grant Colleges and Universities, Columbus, Ohio, November 11, 1953.

in many lines. As long as military service continues, a medical student can hardly hope to enter civilian practice in less than nine years after graduation from high school. If he becomes a specialist, it may be fourteen. This gives an age range from twenty-seven to thirty-two. Deferred marriages or burdensome family obligations while studying are socially undesirable. Early marriages and child bearing are more fashionable than they once were; but they are difficult under present curricular patterns. Demand for highly trained and liberally educated professional and specialized personnel is very great, and it will increase. How can we meet the demand without unduly preempting the student's productive years?

We must also be concerned about the cost of education—cost to the student and cost to the institution. Each year added to the curriculum means a cost to the student of one thousand to twenty-five hundred dollars. It means added capital plant and faculty and facilities for the institution. The economic load will be very heavy. It is the misfortune of our generation and the one immediately following to be caught with a double burden. We face the prospect of an adult retired population greater than our country has ever known before and an infant and adolescent population seventy-five per cent greater than it was a decade ago. With our facilities strained to meet the inescapable need, we shall find it dangerous to engage in wasteful and unnecessary duplication. We must put aside the wasteful competitive and duplicating efforts which have been a disgrace to American higher education during the last decade and which have done as much as any single thing to bring it into public disrepute and to give aid and comfort to those who oppose and may even hate us.

Can we provide truly liberal and truly effective professional education more economical of time and money than we have done in the past? It is this possibility which I wish to explore with you today.

Complex Pattern

Our pattern of higher education in this country is exceedingly complex. We possess many kinds of institutions ministering to many kinds of people having many kinds of needs. No doubt each of them has its contribution to make. Perhaps no one of them has the complete answer to all our needs. Of these many types of institutions of higher learning, two are peculiarly indigenous to the American scene; the land-grant college of agriculture and mechanic arts and the four-year college of liberal arts. One is the product of legislation. The other is the product of slow growth and development. Each arose to meet a well defined need of our society.

Section 4 of the Land Grant Act (Morrill Act) of July 2, 1862, provides for the establishment of colleges:

> where the leading object shall be, without excluding other scientific and classical studies and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life.

It seems fair to say that the institutions contemplated by this act were brought into being to provide increased knowledge and skill for those who, at the time, were generally deprived of access to the colleges and universities of the day or who, because of their interest in agriculture and the mechanic arts, did not find in those institutions the subject matter which they cared to study.

We all know how the land-grant institutions have revolutionized American agriculture and have greatly affected progressive agriculture in all parts of the world. I had ample testimony to their worth and greatness this summer when I had the good fortune to be the guest of the University of Bristol (England) on the occasion of the celebration of the fiftieth anniversary of the founding of the Long

Ashton Research Station, now affiliated with that University. There many of the leaders of agriculture in Britain and the Commonwealth paid their high respects to the pre-eminence of American agricultural teaching, research and extension.

By the circumstances of their creation, the land-grant colleges were born free of the customs and curricular patterns of traditional colleges of liberal arts and traditional universities. They possessed a unique opportunity to develop new approaches to liberal and professional education. But, notwithstanding their excellent work in agriculture, have they fully realized the total opportunity that lay before them?

The Morrill Act provided that the leading object of the land-grant colleges shall be:

> . . . to teach such branches of learning as are related to agriculture and the mechanic arts . . . in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life.

While the Act does not exclude the teaching of traditional scientific and classical studies, it clearly contemplates that a liberal education may be obtained without them. It would seem logical to suppose, therefore, that the drafters of the Morrill Act contemplated that liberal education might be accomplished by teaching the subject matter of agriculture and the mechanic arts in a manner designed to produce both a technical and liberal education. But it appears that the development did not take place in this way. Perhaps the way was too uncharted, perhaps the weight of tradition was too great, perhaps the ease of another course was too beguiling for those who, three-quarters of a century ago, were the pioneers in the land-grant college movement. In any case, it appears that in meeting the need for that liberal and practical education, mentioned by the Morrill Act, the land-grant colleges found it more acceptable to introduce traditional courses from the liberal arts colleges or to establish what were in effect schools or colleges of liberal arts within their institutions. They did not, as far as I can discover, develop a new or different concept of how liberal education can be achieved.

To amplify this point, let us now turn to that other peculiarly indigenous American institution, the four-year college of liberal arts.

An American Institution

The four-year college of liberal arts, whether independent or university connected, is a peculiarly American institution. It is not to be found in Britain or Europe or elsewhere outside the United States except where it has been established by Americans or other persons having before them the model of the college of liberal arts as it developed in this country. Perhaps the closest approximation to the four-year liberal arts college in Britain is the newly established University College of North Staffordshire in the English Midlands.

I mention the establishment of this particular institution and the absence of other similar institutions in Western Europe, because we in the United States talk and act as though the maintenance of the great traditions of liberal education in the Western world are somehow dependent exclusively upon the four-year college of liberal arts as it has developed in this country. In doing so, however, we overlook the fact that the great liberal traditions, of which Western Europe has been the custodian for many centuries, have been handed down to us through educational institutions and educational systems which contain no colleges of liberal arts in the sense in which we know them. These great liberal traditions have been maintained and handed on, in the field of higher education, through universities and technological institutions which have taught, in a liberal fashion and in a liberal tradition, subject matter which otherwise would have become purely technical or professional.

To say this is not to minimize the importance of the colleges of liberal arts in this country. They have performed, and will continue to perform, an indispensable service for our people. But because they are so much a part of our life and tradition, we forget that other nations have carried on the tradition of liberal education without them. We forget that it is possible to become liberally educated by the teaching and study of professional or specialized subjects in a liberal manner.

I venture to put this proposition before you with great confidence because I have seen it done. I am a lawyer by profession, and I was an active practitioner for sixteen years. I hold degrees in law from Oxford University and the State University of Iowa. Law is one of the major professions and an exceedingly technical one. That the study and practice of law are, or can be, highly specialized pursuits would seem to be propositions that would require little argument. Whether or not a gift is made in contemplation of death, whether or not a remainder is vested or contingent, whether or not the rule against perpetuities applies to a bequest or a devise, are questions of the utmost technicality. It would normally be thought that the study of such questions or that the study of law could hardly be anything but a narrow, technical and professional pursuit. Nevertheless, during the years 1920–1922, I read law in the School of Jurisprudence at Oxford University, and in my judgment, the study of law in those years was as certain a means of becoming liberally educated as the pursuit of any academic major in any college of liberal arts in this country either at that time or since. It not only embraced the principles underlying the modern law of contracts, torts, real property and other basic subjects, but it also traced the historical and political development of English law and legal institutions from the time of the Norman Conquest to the present day. Further, it provided the student with a perspective on the vast legal development of the Roman world from the time of the Twelve Tables to the Code of Justinian, a broad sweep of almost a thousand years. Certainly such education is designed to stir the imagination and to open the windows of the mind.

Liberal Emphasis

Is there any reason why engineering and agriculture, architecture and pharmacy cannot be taught with the same liberal emphasis and the same liberal point of view that I found in the teaching of law in the Oxford School of Jurisprudence three decades ago?

It seems to me that a negative answer must be made to this question. However, lest you think that I am oversimplifying this proposition and basing it too completely on my limited experience, let me turn for an example to the field of engineering and particularly to the subject of engineering drawing. Not being an engineer, I would suppose that this subject could be excruciatingly dull unless it were taught with the purpose and techniques requisite to stir the student's imagination. The late Professor French, of Ohio State University, gave testimony to its cultural value by pointing out that apart from its practical utility, it can be used to develop "constructive imagination, the perceptive ability to think in three dimensions, to visualize quickly and accurately" and "to build up a clear mental image." And I am indebted to a life-long teacher of engineering drawing for the proposition that the subject can be taught in relation to the broader interests of our time and as a medium for the acquisition of a liberal education.

Engineering drawing, properly understood, is a method of communication—a method which can and does transcend national barriers and becomes international in scope. Mathematics is a method of communication by symbols, printing by signs, speech by sounds, engineering drawing by lines. Thus engineering drawing, treated imaginatively, becomes a part of the total problem of effective communication.

I am aware that much time has been spent on engineering curricula and that there have been argument and debate on the introduction of political science, history, economics and many other subjects into the engineering curriculum. But, bearing in mind that the time engineering students can spend in college is limited and that the pressure for inclusion of additional technical subject matter is very great, has anyone considered how the normal subject matter of engineering can lead to the civilizations of the Nile and of the Tigris and Euphrates, to the construction of the temple to Jupiter at Baalbek, or of the Parthenon at Athens or of the Colosseum at Rome? Surely engineering drawing is not unrelated to ethics or logic, or to economics, or to the graphic and plastic arts, or to the temples which have housed the great religions of mankind. Engineering drawing can be taught with deadly dullness or it can be taught so that it will open the windows of the mind. Let the contribution of the teacher of engineering drawing, as my friend so well put it, "be like flashes of light stabbing through the dark areas over and above and beyond his subject matter, illuminating for one bright moment vague spots in the engineering educational shadows." [1]

Doubtful Proposition

While in general I would support the proposition that there are some things which every liberally educated man should know, I fear that we have been led into error sometimes by believing that the study of certain subject matter inevitably results in a liberal education. This is a doubtful proposition. It is nearer the truth to say that there is no subject matter, worthy of a place in the curriculum of a modern land-grant college or state university, which cannot be taught either as a professional speciality or as a liberal subject.

For example, there is no specific efficacy, for one seeking a liberal education, in a knowledge of the declension of Latin nouns or the conjugation of Latin verbs. One who learns a foreign language for the purpose of purchasing a ticket on an airplane or ordering a meal in a restuarant or in order to sell more automobiles or hats or shoes is probably not studying it in the spirit of liberal education. On the other hand, one who studies it and its literature in order that he may have his eyes opened to the nature and extent of a new civilization different from his own is in process of obtaining a liberal education. I have long thought that the general principles of the law of evidence should be mastered by every graduate of an institution of higher learning. It has implications and value far beyond its technical significance to the lawyer. Mathematics is an international language. It can be taught as an intellectual exercise, completely divorced from all social significance or reality. Or it may lead to the land measurements of the Egyptians, the construction of the Pyramids, or the dimensions of the solar system. Knowledge may be so departmentalized that chemistry can be taught in courses in chemistry and English composition be taught in courses in composition so that never the twain shall meet. Or chemistry may be taught so that every teacher of chemistry is also a teacher of English speech and composition, just as every teacher in every subject should be. He should possess a mastery of the fundamentals of the language and should possess and be able to induce in others a sense of style, for, as Whitehead says, "Style is the ultimate morality of mind."

I have dwelt on this point at some length because of the apparently erroneous belief that land-grant colleges must duplicate the work of liberal arts institutions in order to provide their students with that attitude toward life which we believe to be characteristic of the liberally educated man. What seems to be completely overlooked is the possibility

[1] Higbee, *Journal of Engineering Drawing*, Vol. 12, series 34, Feb., 1948; p. 8, at p. 24.

of teaching professional and technical subjects in a liberal manner, in other words, providing for a liberal education in professional curricula.

Each of us has had the experience of finding subject matter come alive because of the presence of a great teacher. We know that the influence of the teacher is determined not by his subject matter but by his handling of it. Otherwise the greatest teachers would all be in one field. But we know this to be contrary to fact.

Opening Vistas

What we need in our land-grant colleges and universities and institutions of technology are teachers of professional and specialized subjects who see their subject matter in relation to the whole field of modern learning and modern civilization. In an institution possessing such teachers and likewise possessing an imaginative and intelligent student body, liberal education is bound to occur, whether the subject is contracts or classics, physics or politics, anatomy or art, soils or sociology, history or hydraulics. To use words which may have become slightly shopworn and overworked in recent years, we need teachers who teach with a sense of the "infinite and urgent." We need teachers who see their subject matter not only as a means for developing techniques and skills, vitally important as these are, but also as the means for opening vistas which will challenge and inspire the student's imagination.

The land-grant institutions, having been created free of the habits and traditions of the past, have an unequalled opportunity to explore and develop the possibilities of liberal education in their professional subject matter. It is not a legitimate objection to say that the curriculum is too full and that there is no time for this kind of education. True enough we hear that the subject matter of each professional field is increasing, and, therefore, that the curriculum must be lengthened. This rests on the fallacy that everything must be taught. Yet what a fallacy that is! No lawyer ever learned all the law he practices in the school or college in which he studied. The same is true of the doctor, the farmer, the engineer, the journalist and of every professional man. No institution dares demand the time necessary to teach its students all there is to know. It is the responsibility of the institution, perhaps its most important responsibility, to determine what is fundamental, to teach that which is fundamental, and then to put the student on his own. We need to review our curricula often. We need to view them with a practiced eye and to re-evaluate and eliminate and consolidate until we have only the fundamentals remaining. What we teach should be basic. It ought to lead the student out to those things which he can learn for himself, and it should be taught with that imagination and vision, that liberality of mind and spirit, necessary to assure that what the student learns will be learned in relation to the whole complex of modern knowledge and modern civilization.

Widened Horizons

If this can be done, thousands of young men and women who otherwise might become merely narrow technicians will become not only able and effective citizens, but even their professional competence will be heightened, because their eyes have been opened and their horizons widened to things far beyond their childhood gaze. And because we have taught them imaginatively, they will be stimulated to be students as long as they live.

If this can be done in your institutions and in ours, we shall have succeeded in creating a new form of American education, a form both liberal and competent, complete and economical, and, therefore, admirably adapted to serve the needs of students, of our institutions and of society as a whole.

In my judgment, this possibility is the most challenging one which has come to American education in many years.

It Is Time for the Laymen to Come In*

By J. F. CALVERT

Professor and Chairman, Department of Electrical Engineering, Northwestern University

Introduction

The Chairman of the Humanistic-Social Division has asked me to speak in relation to the abilities and work methods required for the solution of new and unfamiliar engineering problems.

I imagine that many have wondered why, of all living creatures, man has been so singularly and bountifully endowed with problems. Although the situation remains inescapable, what to do about it has led to quite interesting speculations. It is common practice nowadays to ascribe our chief difficulties to the fact that scientific and engineering advances have outrun our abilities to use them. One ingenious theory undertakes to get rid of our responsibilities in the dilemma by simply restating the problem. The theory credits our ills to the machine age. The idea possesses an interesting genealogy for, while in the middle ages it was popular to assign the evils of the world to the work of the devil, modern writers have managed to endow "the machine" with a personality and to then make it their whipping boy. The appeals are similar, and equally satisfying, since each presents something with the likeness of a human being which the majority may decry. However, to replace a personality of doubtful existence by simple physical equipment, bears all the earmarks of a modern miracle and, oddly enough, places upon its authors a certain responsibility for technological unemployment.

We can abandon this approach, for in education we have one which enjoys even greater popularity. Stripped of academic adornment, it says: If we have more study in the humanities relative to the amount in science, we may expect a better world to live in. I take the liberty of passing along two illustrations from several which were summarized in a recent paper by Rhodes R. Stabley, published in the Bulletin of the A.A.U.P.

In the words of Mr. Stabley one prominent educator "held that a liberal arts program with its stress on human understanding and with a positive approach to essential values, is of greatest importance to society." And from the same paper I learned that the president of a well known university contends that students with a good liberal arts education are "the least likely to become associated with communism."

There have been many expressions of faith like these and, though occasionally vague, it is quite clear that we all believe in them. The liberal arts faculties ask us for more time, and we in engineering work busily on curricula to see that this is accomplished. There is the implication of success if only we apply the formula. But, we have had pilot plants going for many decades; should we ask how they are getting on? Do we really find that morality and high purpose among college graduates can be measured by the relative number of college hours expended in one area as compared to those in another?

Then there are the scientists, pure and applied. Many of us feel that our brands of education must afford the best preparation for life in this technological age.

* Presented before the Humanistic-Social Conference, Annual Meeting of A.S.E.E., University of Florida, June, 1953.

I shall refrain from quoting any of our people because I live among them, and so far have liked it. Besides I cannot recall how many times I've said: "Now, let us talk about an engineering stem for the liberal arts program." So there still exists in my mind a slight gnawing fear that even we could appear a little self-satisfied, at least to the uninitiated.

After what I've said thus far, I trust that the ideas yet to be expressed in this paper will in no way appear revolutionary. Now one may be led to suspect that since in all education we seek to know the truth as we are enabled to see it, our approaches may have something in common. In consequence, there may be unearned increments, carry-overs into areas for which the methods were not really designed.

I want to suggest that, at least for the engineer's training, something further might be gained were greater efforts made to relate historic truths and the recognition of values to rather specific present day problems. I think it not inconsistent with gaining understanding to have our engineering students given more practice in distinguishing, stating, and attempting to propose solutions for problems in the broader areas of their future work. It is the consideration of such possibilities which I believe your chairman had in mind when he established the theme for this meeting. I plan, now, to say something of the principles of problem-solving for technical engineering work and then to conclude with a few remarks on the possible applications of somewhat similar principles to the training of future engineers for the more general phases of their professional careers.

Problem-Solving in the More Technical Areas of Engineering

This discussion of engineering problem-solving will be divided, for clarity, into four sequential parts. Actually, an engineer is rarely able to work through a problem in such an orderly fashion. Indeed, he may travel back and forth many times from one phase to another before he achieves a solution. Nevertheless, just as it is helpful to the engineer, so it may be to those of you interested in his work, to have a brief, if somewhat idealized, delineation of his more creative activities.

Discovery of a Human Need

All problems seem to stem from the discovery of a human need or want. At first the need may be expressed, or even unexpressed and, if the latter, evidenced only by a state of discontent. Not surfeited by problems which are thrust upon us, a certain number of engineers intrigue themselves with potential needs, which appear largely through the imagination. A man thinks, "If only I could produce thus and so, people would like it; I could be in a new and, perhaps, more rewarding business." If a want can be satisfied entirely, or in part, by the application of knowledge of the physical sciences, it becomes an engineering problem. In our country we usually approve of this sort of activity and certainly many enjoy it.

However, it is a fact that the engineer often fails to recognize even the actual existence of a need, not to mention those which exist potentially. The reasons are not too surprising. In college he has learned how to solve problems which the teachers or the texts brought to him. Rarely, if ever, did he have to find one on his own. But there are ways around this. Human needs can even be organized into groupings and the student can define a specific problem. Without trying to produce a logical table of these needs, there come to mind—the preservation of life, safety, transportation, communication, the reduction of physical labor, the economic use of materials, the preservation of resources, and also the development of recreation and amusement facilities. In going concerns, such as the telephone business, there are groups of engineers assigned the task of working eight hours a day with the business as they expect it to be three to five years hence. Colleges provide little practice for this sort of or-

ganized thinking and almost none for those men who may contribute substantially to the creation of a new form of endeavor. On this basis, it might be desirable were we more concerned with developing the student's sensitivity to such existent and potential needs. To become most effective the engineer's training might give more directed practice in observing social and physical surroundings, practice in listening and evaluating, and practice in listing observations for further study.

Statement of the Problem

Having become convinced, though not necessarily by a completely logical process, that a legitimate problem exists, the obvious next step for the engineer is to get it stated clearly. This might be done in one of several ways, but a representative form was suggested to me by the late Dr. Robert H. Seashore, Psychologist at Northwestern University:

(a) The object is to design: .....
(or) to produce: .....
(or) to organize: .....
(or) to adjust: .....

} And here the engineer must state what it is.

(b) In order to overcome the following obstacles: .....

} And here he must set them forth as completely as possible and attempt to indicate relative importance.

(c) In such a way that the following specified aims will be achieved:

} And here, too, he must set forth items showing, perhaps, necessary minimum requirements below which he should not go, and maximum values beyond which no appreciable advantage is to be gained. A grading procedure is desirable for comparing alternative solutions (when discovered) which fall within these bounds.

The engineer should not expect to advance in one leap from the recognition of a human want in nebulous terms to such an accurate statement of the problem, but he should strive for such a statement with minimum delay, even though planning to hold his initial definitions as tentative. Quite often it is practicable for him to start the search for an actual solution *after* the problem has been stated in accord with these three main items, but *before* all measures for relative evaluations have been established.

The Synthesis of Potential Solutions

The teaching of science and of engineering relies to a large extent upon analysis (quite mathematical in character) for both generalization and for demonstration. At this point two simple definitions may be helpful. Let us say that a "basic fact," or "law," is a concept we can use more often than some other relation, and that mathematical-like statements are ones phrased in a language which can be employed without ambiguity. We lump these together under the term "fundamentals" and emphasize their use in all scientific education; in fact, their manipulation forms a large part of the "scientific method." At times, one detects reverence, even mysticism, in the use of these terms; but, I believe that in both scientific and engineering education, while we emphasize facts and techniques of analysis, we actually have produced only a few procedures (some of which are mentioned in this paper) for developing a sort of wisdom in the use of these teachings. To a large extent, we simply trust that from experience in research or engineering

practice, this wisdom will grow in a somewhat undefined manner.

In engineering we know that truly new products and/or organizational procedures are not often born as the result of pure analysis, but are synthesized by bold thinking—first in qualitative terms where they are painted in sweeping strokes with a broad brush. Sikorski speaks of intuition as the "forerunner of knowledge," which tells of the correctness of things that later may be proven by observation and analysis. Synthesis stems from the imagination, a series of forms, colors, sounds or images appearing within the mind, and intuition is that sense of correctness which alerts you for a conscious check. The check itself may be either preliminary and not entirely conclusive, or it may be carried out by the stern processes of analysis. The search for a solution calls for quick tentative uncertain probings, and only the accurate check is in accord with flawless logic. Creative work in engineering calls not only for a knowledge of science and industry, but also for the spirit of art; yet there are definable abilities and work methods which can be useful in the initial stages of problem-solving, and which a man can develop through practice.

Two of the special abilities we might call idea fluency and originality. Idea fluency could be defined as a quantitative concept, concerned both with the recognition of problems needing solution and with the proposal of numerous possible procedures for the solution; while originality could be regarded as qualitative concept, the ability to produce ideas which are uncommon, clever, or remote from the traditional.

First among the work methods is that of converting the statement of the problem from one goal to a sequence or group of sub-goals, where, if each is attained, the whole or single major objective will be achieved. There comes a rather long "soaking in" process in which one gathers facts and hunches (appropriately tagged), and then lives with these day and night —always with the main and tentative sub-goals in view. Library searches bring to mind well defined procedures, but there is an art in asking pertinent questions of experts and then actually using the answers in research. Today this art is largely self-taught.

Conference Approach

There is at least one conference approach which should be mentioned. In the past, it has seemed to me that the chief and often fatal drawback of many group discussions was that members of a committee not only could but would "shoot full of holes" almost any newborn idea before it had time to get its legs under it. A procedure for avoiding this difficulty, recently brought to my attention by Frank R. Benedict of the Westinghouse Electric Corporation, bears a mild resemblance to the game laws. It is agreed at the start of a meeting, and then strictly adhered to, that for a time no man may enter a destructive remark. No one speaks except to get onto the blackboard a possible method of solving the problem. An optimistic or enthusiastic outlook is encouraged. This is continued until all suggestions seem to have been extracted from the group. After this idea stage has served its purpose a classification of the possibilities is undertaken, but, again, without destructive criticism. Next, the relative evaluation of ideas, is undertaken, but still with some spirit of forebearance. In the final stages, however, at this or a subsequent meeting, the cold hard restrictions are firmly introduced to eliminate the unpromising proposals and, in fact, to choose that or those upon which action will be taken.

As the work proceeds sub-goals must be rearranged, modified, discarded, and replaced as one checks for matches and mismatches between tentative solutions and the written sub-goals, main goal and human want. This calls for the development of another ability which might be called mental flexibility. It involves both the willingness and the ability to change "set," or viewpoint, or the mental picture

of the procedure to be used. It is objectivity but with the idea of observation followed by action.

One standard procedure employed in the solution of physical problems is to attempt the replacement of the original situation by a much simplified version, or model, which the investigator believes will act in a manner similar to reality. To be useful, the fiction introduced should be one which will yield a solution, and it should be one onto which the engineer can add complexities as he becomes better able to achieve solutions. His purpose is to construct and solve successively more involved models which progressively take on greater and greater resemblance to the real or originally assumed physical situation.

All such efforts in creative work or problem solving are hard and decidedly wearing. They always engender fatigue; often exhaustion and a sense of utter frustration. There results a loss of mental power, verve and flexibility. The engineer must not only recognize the symptoms in his own behavior, but should develop for himself his own ways of minimizing the duration of the ensuing periods of relative uselessness for the job at hand. He must devise ways to regain strength, enthusiasm and flexibility.

Finally, let us suppose that the engineer finds one or more potential solutions to his main or original goal. If he has found more than one, he must weigh their relative merits. Sometimes he is forced to carry along two or more developments, but this is a costly procedure in the use of manpower, and usually of material. Hence, as early as possible, he must devise ways of testing one procedure against another. Often both long and short term aspects of his problem are to be considered. He asks such questions as: How will this affect sales or labor or financial policy this year and five or ten years from now? On problems of very broad implication he may be the one who must ask, "How will this affect, in a given region of the country, income, the preservation of natural resources, or general human welfare?"

The Selling Problem

Throughout any development, as well as at the end, the engineer must sell, and sell, and sell. He must secure funds, quiet the skepties and faint of heart, enthuse personnel, gain time, persuade vendors of materials to speed lagging deliveries, secure compromises between conflicting opinions within his own group without watering down the ultimate goal; and, at all times, he must keep the job moving. Then, oddly enough, to be successful he must seek general acceptance of the finally created result.

Training for Problem-Solving in the Less Technical Areas of Engineering

Engineering is dependent upon study in many areas: mathematics, physics, chemistry, business economics, English; and, I may add, very appreciably upon a continuing study in the humanities, extending over many years. But engineering is no single one of these. American industries are dependent upon materials, trained workers, economics, scientific discovery, and the law. But, American industries as we know them today, particularly in the durable goods areas, would not exist on the basis of these alone. These industries were planned and put together by engineers. In consequence, engineers in swelling numbers are assuming the rolls of both major and minor executives. It is reasonable to expect that in the future they will be consulted in increasing numbers in relation to government and world affairs where their particular planning skills and experience can be of value. Potentially, these are the kinds of men whose growth we are trying to influence through their college experiences.

It is well recognized that the engineer must prepare for problem-solving in many areas considerably removed from the purely technical. It has been generally assumed that some exposure to the

conventional courses in the humanities would provide this needed preparation. It is considered self-evident that such experience affords an opportunity for developing a richer intellectual life by providing access to knowledge and a desire to know more of man and of the universe which he is privileged to see. *Also*, it has been *tacitly* assumed by many that such educational experience has been close to the best possible for preparing a man to take appropriate action in the affairs of his adult life. But, by itself, the latter assumption seems not too conducive to changes in educational methods and, in consequence, may inhibit potential improvements. So, at least for the purposes of this discussion, I shall contend that to blindly apply this latter belief to the future of engineering education, certainly would represent an unwarranted assumption of faith in the status quo. It might better be said to represent an improper continuation of time-honored shibboleths passed along by the static minded educators of the past.

Along with most in engineering and science, I believe that abilities for problem solving are developed through doing. A little may be learned of this through reading and observation, but much more through practice. We need to ask now: What are the obstacles to a further development of these needed educational experiences?

First, let me record a few observations. From time to time I have asked colleagues from various parts of the campus what they thought of the following as representative of subjects for doctors' dissertations:

(1) A discovery in the physical sciences.
(2) An invention or all new design in engineering.
(3) A novel.
(4) A musical composition.
(5) A painting.

Each presents possibilities for truly creative work, yet the foregoing are arranged in what has appeared to be the decreasing order of acceptibility. Rather scholarly explanations were advanced by some; other wondered if there were not just two really important reasons: the decreasing possibility for gauging results coupled with a genuine and, in our times, a particularly commendable desire to avoid the bizarre.

Related Observations

There seem to be related observations. One gains the impression of growing trends in many areas of study toward the collection of facts, the employment of statistical-like procedures, emphasis on minute detail, and the constant employment of analysis for refinement. All are necessary, and in certain areas, such as the social sciences, perhaps these are particularly desirable as means for "quantizing" hitherto qualitative information. Perhaps the danger today is not that we fail to do enough of a scientific nature, but that in evaluating research we fail to distinguish facts and techniques from creative work. Surely, the standards we set for our research affect our undergraduate teaching. I suspect, in consequence, we may tend to teach what we can measure and are a little too pleased when it comes back neatly packaged in punch boards, blue books, and term papers none the worse for wear. Whether we teach a fundamental law of physics, a manual skill, the appropriate substitution in a differential equation, or accepted forms for written English, perhaps we should recognize that, while once new and novel, these are now accepted facts, data and techniques. Like a knowledge of materials, tools and the skills of true artisans, these are essential, but by themselves will not develop the wisdom of the planner or the architect.

At our present meeting we intend to look at the engineer's training in the humanities with problem solving in mind. By way of introduction, consider what are perhaps our most obvious problems of the day—social and political affairs

on a world wide basis. All of us are becoming increasingly aware that ideas, almost as if by osmosis, seep both ways at once through all political boundaries. The great question is: Which will predominate? But the more practical questions are: What do we believe? How strongly are we dedicated to these beliefs? How aggressive will we be in spreading our beliefs? And then, in relation to the present discussion: What may be said of education as a preparation for those who must point the way to successful procedures?

During the past century our colleges produced men of conviction and zeal. It seems to me now, that beginning in the twenties, we became a little uncertain, self-conscious, and for a while sophisticated; and so we tended to produce samplers, tasters, critics, and passive observers. Now during my life time, we have experienced expanding dynamic political forces motivated by philosophies of empire and rights to leadership, theories of a dominant race and human destiny, and, more recently, an aggressive and frightful cult called communism. All have been authoritarian and each more barbarous than the last. We found the passive outlook was not good enough, probably not even good enough to provide for our own survival. Apparently, we've decided there is greater power in being for one ideal than there is in just being against another. I think it is in consequence that we have had a revival in the emphasis on human rights and principles of self-government. These rights were succinctly stated in an address in 1946 at White Oaks, Maryland by Dr. M. A. Tuve as: the right to know; the right to believe; the right to differ; and the right to be an individual. For our purposes here we may add as principles: the sovereignty of the people; and the provision through the forces of law for reasonably prompt justice and for means of peaceful change. These have been reemphasized in school, press, and statements of public policy to serve as motivating forces. Certainly they are working methods whose values have been proven over the centuries, and so we justly consider them absolute essentials. Yet by themselves, even these are not the strongest motivating forces. Somewhat to our disappointment, they did not sell too well, particularly in the Orient; and so we were inclined to say that the first needs of peoples were food and clothing.

Powerful Forces

We remember that survival was once called the first law of nature, but while it may have been the first from an evolutionary point of view, it is demonstrably not always the most powerful force; so let us ask, what beyond survival do people want? I suspect the most persistent is evidenced by a desire for the approval of their associates, and then again they yearn to respect that which they will see when they look inwardly upon themselves. These hoped-for-approvals are measured against certain standards and we may as well face it—the most powerful forces in the minds of men, it appears, have been and are religions, philosophies and ethics. Whether the end results have been for the long time good or bad, only these forces seem to have brought purpose and satisfaction into human lives, and only to these will peoples become truly dedicated.

While, I believe, we will return again to the old premise that for understanding we must give most thought to human motivations, I am fully convinced that, more than ever before, we must be concerned with problem-solving—plans and actions based on a knowledge of these motivations. With the engineer's education in mind, let us take a further look.

During the past century, we in the western world have found our ideals and purposes much like drops of mercury on a table—though unable to pin them down, still we could not deny their shining existence. Without extolling a special viewpoint we should open wide the windows, that each student, from his own point of view, may not only see these bright spots of light which lie before him, but recog-

nize them as the reflections of light from a great single source—one which should influence the whole—his studies and his life.

Suppose for the moment that we were to learn to do just this with care, candor and humility. Then, let us look at problem solving for the engineer in relation to his general studies. Consider his opportunities to view labor-management relations; race-relations; area developments (such as TVA) here and abroad with their related soil conservation, population and associated problems. (And here we must add a consideration of the ever present need for individual motivation and incentive.) From the same basic viewpoint consider the student's opportunity to study the effects of tariffs and subsidies; and, let us add, to investigate some of the public school problems of the day. Let us ask, does he have practice in finding, stating, and limiting problems? Against what does he measure the value of his goals? Does he consider potential opposition, and limitations in the ability to achieve these goals? Does he synthesize potential solutions in terms of long and short time aims? Does the student consider to whom he would "sell" an idea and how he would proceed to do so?

It Is Time for the Laymen to Come In

Now, at last, I have come to the title of this paper. It is obvious that within the time available, we cannot hope to make of student engineers, scholars in any of the areas of the humanities. In this sense the engineers remain laymen. Yet, they are expected to become men of action, busy with problem-solving and decision making, at home and over-seas, in broad areas of human affairs. There are more than three hundred thousand engineers in this country alone. Their recommendations and decisions will affect the lives of many. True scholars in the various specialized areas of the humanities are fewer in number, and most of these remain at the colleges. It is upon laymen such as the engineers that we must rely for many changes and, hopefully, we say for improvements. There exists a responsibility to develop these men not particularly in the direction of scholarly attainment in specialized fields, but for problem-solving based upon a working knowledge in many areas. It's for all sorts of reasons I wish you well with our common responsibility; I hope you feel as I do, that it is time now for these laymen to come in. They should be helped to come fully into their own through the training we give them—particularly through the way we encourage them, not only to learn and to understand, but to discover problems, to state problems, to solve problems and to reach decisions for appropriate action.

An extensive bibliography is available to anyone who wishes to write the author for a copy.

Free Film Available About "Mechanical Engineering"

Michigan State College has completed a vocational guidance film about "A Career in Mechanical Engineering" which they have agreed to loan to interested groups without charge, except for shipping costs. This 20-minute colored film shows the nature of mechanical engineering, job opportunities, and training given future engineers.

Designed primarily for showings before high school groups interested in engineering careers, the film includes scenes of training on the Michigan State College Campus, and professional engineers at work in industrial plants. A mimeographed script accompanies the film. Requests for the film should be sent to Professor W. E. Libby, School of Engineering, Michigan State College, East Lansing, Michigan.

Proposed Amendment on Membership Dues

An amendment to ASEE By-Law IV relating to dues of individual members will be submitted to the Society membership for vote in April. This change in dues was recommended by the Committee on Society Finances in June 1953, after careful examination of the financial operations of ASEE. The report submitted by the Committee on Society Finances was approved by the Executive Board of the ASEE, the Engineering College Administrative Council and the Engineering College Research Council. This report was published in the September 1953 issue of the Journal of Engineering Education. The General Council discussed this problem at its meetings in June and October 1953. In the October meeting, the Council voted unanimous approval of amendments to increase the dues. The following amendment embodies the same dues rates as that previously voted upon by the Council but is a simplification. It was unanimously approved by the Executive Board and is now being resubmitted to the Council for vote.

Proposed Amendment to ASEE By-Law IV

"Individual Members

Within the ceiling limits for dues hereby established, the dues of members may be adjusted annually by the General Council at the same Council Meeting at which the annual budget is considered. The dues shall be so adjusted within the ceiling limits hereby established that over a reasonable period of years the Society shall not incur a deficit that in the opinion of the General Council might endanger continuity of operations.

The ceiling on dues shall be $7.00 per year for those who have not reached their 36th birthday at the beginning of the fiscal year (July 1) and $10.00 per year for all other individual members. Except for the first year after the adoption of this By-Law, the increase in dues approved at any one time shall not exceed $1.00 for individual members.

During the first year after adoption of this By-Law, the dues for individual members will be $6.00 for members who have not reached their 36th birthday by July 1, 1954, and $8.00 for all other members.

Institutional Members" (The remainder of By-Law IV is unchanged).

Present Wording of By-Law IV

IV. The annual dues shall be as follows:

Individual Members

1. Librarians and grades under Associate Professor	$ 5.50
2. Associate Professors	6.00
3. All others	7.00

Institutional Members

1. Active Members	
a. Participating in both Institutional Councils	$50.00
b. Participating in only one Institutional Council	35.00
2. Associate Members	50.00
3. Affiliate Members	25.00

A Proposal for Obtaining Necessary Income for the Society

By HUBER O. CROFT

Chairman, Committee on Constitution and By-Laws; Past President, ASEE

President Grinter in the November 1953 issue of the Journal gave the following facts concerning the financial operations of the Society:

1. The dues have been increased only from $5.00 to an average of $6.25 in the past twenty years.
2. A deficit of $1,700 was experienced last year and a budgeted deficit of $3,700 is occurring this year.
3. The cost of publishing the Journal now amounts to an annual charge of $30,000 or 40% of the income of the Society. Investigations of other methods of printing the Journal indicate that very little if any savings can be anticipated.
4. The Society operates with a very small headquarters staff and low overhead expense. At least one additional clerical worker should be added to the office staff.
5. The Society pays no rent for its headquarters space and furniture.
6. The cost-of-living index has just about doubled since 1946.
7. The ASEE has maintained a balanced budget until last year by a vigorous expansion of membership and a substantial increase in other Society revenues. However, these efforts have themselves entailed additional operating costs.
8. In order to maintain the Society in a healthy condition an increase in the dues of individual members is essential.

On the opposite page is shown a proposed substitute for the present Fourth By-Law of the Society which pertains to the annual dues of the Society. You will be asked to vote on this proposal by a letter ballot which will be mailed to you in April, 1954.

The original plan for increasing the dues of individual members was suggested and approved by your General Council and the proposed wording of the substitute By-Law has been approved by your Committee on Constitution and By-Laws, consisting of: H. H. Armsby; H. P. Burden; G. A. Marston; K. B. McEachron; H. P. Rodes; and H. O. Croft, Chairman.

The officers of your Society recommend the adoption of the substitute By-Law and ask your support.

ASEE Summer Institutes—1954

Science and technology are moving rapidly ahead in broad areas which hold significant promise for the future of engineering. In order to assure maximum progress in engineering education and to expedite the translation of new fundamental concepts into engineering practice, the American Society for Engineering Education is inaugurating this year a series of conferences to be known as Summer Institutes. This program will help to implement the recommendation of the ASEE Committee on Engineering Education that modern physics, including nuclear science and solid state physics, should become an essential study in engineering education.

Each Summer Institute will deal with a specific subject matter area. The purpose of the Summer Institute is to seek out and clarify fundamental concepts, to assess the material as to its importance in engineering education, and to arrive at a logical orderly pattern for teaching purposes. By this positive approach, it is hoped to bring engineering education into closer proximity to the significant new developments which will affect its future. In these conferences, the divergent viewpoints of the research engineer, the scientist, and the educator will be brought to bear upon the problems.

Two Summer Institutes are planned for 1954—one in Sold State Physics in Engineering Education and the other in Nuclear Physics in Engineering Education. Both conferences will be financed by grants from the National Science Foundation. Each Summer Institute will consist of a working conference of 20 to 30 leading authorities in the particular field who will make a comprehensive analysis of the material and lay the groundwork for the open conference. The open conference will feature about 6 to 8 of the participants of the working conference, discussing important fundamental concepts and organization of the subject matter as it relates to engineering and engineering education. There will be ample opportunity for open discussion by those in attendance.

These conferences are supported in part by grants from the National Science Foundation. The American Institute of Physics is cooperating in the Nuclear Science Foundation.

Solid State Physics in Engineering Education

University of Illinois—March 8–10, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Carnegie Institute of Technology—June 21–25, 1954

Open to engineering and physics teachers. Attendance will be limited to 150. For information and registration forms write to Professor John W. Graham, Carnegie Institute of Technology, Pittsburgh, Pa.

Nuclear Science in Engineering Education

Columbia University—April 22–24, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Northwestern University—September 7–11, 1954

Open to ASEE members. Attendance will be limited to 100. For information and registration forms write to Professor Robert L. Young, Technological Institute, Northwestern University, Evanston, Ill.

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ASEE Summer Schools—1954

The following Summer Schools, sponsored by ASEE Divisions, are open to ASEE members. For information and procedures as to registration, please write to the person indicated in connection with the particular Summer School. All of the Summer Schools at the University of Illinois either precede or follow the Annual Meeting so that those in attendance can combine Summer School attendance with attendance at the Annual Meeting. The program for the Annual Meeting of the ASEE will be mailed to Society members during the last week of April.

Economics of Engineering Summer School sponsored by the Engineering Economy Commitee.

Theme: "An Evaluation of Analytical Techniques of Engineering Economy."
Time: June 12–13, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Arthur Lesser, Jr., Head, Industrial Engineering Dept., Stevens Institute of Technology, Hoboken, N. J.

Electrical Engineering Summer School sponsored by the Electrical Engineering Division.

Theme: "The Elements of Design of Digital Control Circuits."
Time: June 18–20, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Dr. L. V. Bewley, Dean of Engineering, Lehigh University, Bethlehem, Pa.

Summer School in Advanced Engineering, with Emphasis upon Development of Creative Thinking jointly sponsored by Educational Methods Division and General Electric Co. Attendance by invitation only.

Time: Aug. 30–Sept. 4, 1954. *Place:* Schenectady, N. Y.
Information: R. H. Buescher, Technical Education, General Electric Co., Schenectady, N. Y.

Workshop for Humanistic-Social Study Project sponsored by Humanistic-Social Division.

Time: June, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Sterling Olmsted, English Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

Engineering Mechanics Summer School sponsored by the Engineering Mechanics Division.

Theme: "Evaluation of the Engineering Significance of Graduate Training in Mechanics."
Time: June 11–12, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Dan Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

Summer School sponsored by the Mechanical Engineering Division.

Theme: "Teaching of Machine Design and Manufacturing Processes."
Time: June 18–25, 1954. *Place:* University of Illinois, Chicago, Ill.
Information: Professor K. E. Lofgren, Machine Design, Cooper Union, New York, N. Y.

Correction

The talk of Prof. H. E. Hoelscher of the Johns Hopkins University at the National Capital Area Section meeting this fall was reported incorrectly in the November issue of this *Journal*. Prof. Hoelscher discussed the report of the Johns Hopkins Educational Committee. This was a general report and not directed at the Hopkins Program specifically. The Hopkins does *not* provide a split curriculum, and has *no* five year undergraduate program in Engineering of any title. The Hopkins New Plan, discussed by Dean Roy (not Ray, as reported in the same issue), provides a maximum amount of individual freedom of choice for the undergraduate student, emphasizing the importance of the fundamentals of mathematics and the basic sciences for students in the Engineering School, while permitting them to progress in their studies at a rate dictated as far as possible by their own talents and abilities.

Survey of Engineering College Needs for Basic Research in the Engineering Sciences*

By RALPH A. MORGEN

Program Director for Engineering, National Science Foundation

Introduction

In the past two decades there has been a profound change occurring in the philosophy and needs of engineering education. A growing emphasis is being placed on the importance of graduate education and the consequent need for more research as a concomitant part of the process. The concept of the engineering sciences has developed as a necessary tool to accomplish the needs of advanced engineering education to supply the practicing engineer with the information needed in light of rapidly advancing technology.

Since graduate education is expensive compared to undergraduate education, the problem of financing this new program is a vexing one. During World War II and subsequently, the engineering colleges have had the opportunity to finance this growing graduate program through contract research with funds largely arising from federal agencies charged with national defense. It is recognized that continued support for the graduate research program is needed.

This survey was undertaken with the thought of determining several factors: First, the present status of graduate education and research in various engineering colleges? second, the potential now extant to perform the necessary task of increasing the supply of engineers with advanced degrees and third, to make a rough estimate of the minimum financial needs to meet the requirements.

Although some data in this study are presented in statistical form, the methods of data collection and analysis do not permit a strictly quantitative interpretation of the figures. The statistics should rather be viewed as essentially a gross indication of the general magnitude of the problem.

The study was confined to the 149 educational institutions which have one or more undergraduate curricula accredited by the Engineers' Council for Professional Development. Of the 149 institutions, two are service institutions, the United States Coast Guard Academy and the United States Naval Postgraduate School. These two were not included in the survey. The remaining 147 institutions were contacted and specific answers received from 139 of the institutions. Of these 139, 63 institutions were contacted personally by direct interviews. Rather detailed letters were received from key † persons at the other 76 institutions.

Each university was asked the same basic questions. The discussion is based on the answers to these questions.

Research Policy

The first question asked was:

"What is your official policy relative to staff loads and time allocation for

* The opinions expressed in this paper are the author's and do not necessarily represent the views of the National Science Foundation. The data presented are not to be construed as official statistics of the Foundation.

† By key persons is meant the Dean of Engineering, Director of Engineering Research, the Graduate Dean or a cognizant Department Head.

staff research? In brief, how do you encourage your staff to engage in research?" The purpose of this question was to set the stage for the more specific questions which followed.

The responses to this question fell into three general categories.

Category (1): There was a rather small number of institutions in which the climate for research was quite unfavorable. Several institutions of this group stated that they were not interested in having their staffs do research. The number of institutions which fell into this category was 14 or 10.1% of the 139. This group is designated as (A) in Table I.

Category (2): The next and largest group of institutions is the one where there was some interest in research but the amount of funds for research support was so limited that the research potential of the institution was badly handicapped. Seventy of the 139 institutions or 50.4% fell into this category.

TABLE I

ENGINEERING SCIENCES RESEARCH SUPPORT BY INSTITUTION

Classification of Institution	Number of Institutions	Per Cent
(A) The attitude of the administration is unfavorable to staff research in the engineering sciences.	14	10.1
(B) The administration gives *passive* support to research in the engineering sciences but no attempt is made to provide funds for staff research from ordinary university sources. All research support must come from outside support such as government or industrial contracts.	31	22.3
(C) The administration gives *moderate* support to research in the engineering sciences. In general teaching loads are 12 or more hours per week with only a minimum number of staff members permitted to have a reduction of load to conduct research on regular university funds. In most cases supervision of graduate thesis is counted as an overload.	39	28.1
(D) The administration gives *active* support to research in the engineering sciences. In general teaching loads are 12 hours or less per week with a moderate number of staff members permitted to have a reduction of load to conduct research on regular university funds. In most cases supervision of graduate theses is counted as part of the teaching load.	29	20.8
(E) The administration expects the staff to contribute to the advancement of knowledge through research or other scholarly work. The teaching load is held to 6 to 9 hours with graduate work given equal or greater value in equating the teaching load than undergraduate courses.	26	18.7
Total	139*	100.0

* There are 149 institutions which have one or more undergraduate curricula accredited by the E.C.P.D. No reply was received from 8 of these institutions, the other two are service academies and were excluded from this study.

However, only 31 of the 70 institutions had no funds for research purposes (designated as (B) in Table I) while the other 39 had some limited research funds (designated as (C) in Table I). Those which had some limited research funds could, in rare cases, lower the teaching load of a particular staff member who wished to conduct research. The greatest deterrent against research accomplishment in this group of institutions was heavy teaching loads. As a result the staff members did not have time to do research, and there were insufficient funds to allow them specific research time. The mere reduction of teaching load would not of itself insure research productivity. Of equal importance was the fact that the annual salary was so low that the staff members had to seek gainful occupation during the summers, usually off campus. None of these institutions had funds for the payment of additional salary to the staff during the summer when the staff was available for research work.

Category (3): The third group of institutions, 55 in all, had climates and administrative support which actively *favored* research by the staff. In these institutions it was recognized that research as well as teaching was an obligation of the institution. However, 29 of the 55 institutions were so cramped for funds that they could not insist that the staffs do research or some professional activity other than teaching. All these institutions had some funds available for reduction of teaching loads during the academic year; however, the additional salary of the staff member during the summer months must be provided from other than university funds (designated as (D) in Table I). Only 26 institutions indicated that they *expected* the staff to do some research or other professional work without additional compensation. This group kept the teaching loads low enough so that research work could be done without making any special concessions (designated as (E) in Table I).

In most of these latter institutions, the salary scale was high enough so that the staff members were not forced to find some other means of livelihood during the summer months in order to make a sufficiently large annual wage to live. Only one institution, however, went so far as to state that all of its staff members who were interested could do research without getting any funds outside the regular university sources. Contracts or grants for research from Federal sources would be considered outside the regular university sources. (Table I summarizes this information.)

Since a doctoral degree in engineering is usually considered a research degree, an attempt has been made to check the validity of the answers received to question one (and consequently the validity of the conclusions that will have to be made on the answers to the other questions). This was accomplished by comparing the answers received from the institutions with the data on advanced degrees awarded by the same institution. The latter information was obtained from the Office of Education.* Table II indicates that there is a direct correlation between the doctoral degrees granted by institutions and the research interest of the administration and staff of those institutions. If the institutions from which no replies were received are omitted from the calculation, and tabulation is made on the basis of the 139 replies, 73.4% (419 out of 571) of the doctoral degrees were awarded by the 24 or 17.3% of the institutions which have the most favorable research atmosphere. If the two top brackets of research atmosphere are considered together as satisfactory for research, then 86.5% of the doctoral degrees (493 out of 571) were awarded by 38 institutions or 27.3% of the accredited engineering institutions from whom a reply was obtained.

While these facts are encouraging, it is disturbing to note that 13.5% of the doctoral degrees were awarded in institutions where the research atmosphere can be con-

* Circular No. 64, "Engineering Enrollments and Degrees," 1952, Office of Education, Robert C. Story and Henry H. Armsby.

TABLE II

RELATION BETWEEN ADVANCED DEGREES IN ENGINEERING AND RESEARCH SUPPORT BY THE INSTITUTION TYPE*

Type of Research Support (See Table I)	Doctoral Awards 1951–52		Number of Institutions Awarding Doctoral Degree	Number of Institutions Awarding Master's Degree Only	Number of Institutions Awarding No Graduate Degree	Total E.C.P.D. Accredited Institutions
	Number	Per Cent				
(A)	1	0.2	1	5	8	14
(B)	25	4.3	6	20	5	31
(C)	52	8.9	20	15	4	39
(D)	74	12.6	14	11	4	29
(E)	419	71.5	24	2	0	26
No Reply	15	2.5	2	4***	4**	10
Totals	586	100.0	67	57***	25**	149

* These data obtained from "Engineering Enrollments and Degrees," Circular No. 364, Office of Education.

** Includes one service academy, U. S. Coast Guard Academy.

*** Includes one service academy, U. S. Naval Postgraduate School.

sidered unsatisfactory. In order for the staff to supervise doctoral dissertations and doctoral candidates' research in these institutions, it is necessary for them to carry this work as an overload above the ordinary teaching load at the institution, or additional funds must be obtained (usually by contract on a year to year basis from some Federal agency) to support the research program including a portion of the staff member's salary. This is not a healthy condition for either the student or the staff member. If a doctoral program is to be meaningful it must operate in an atmosphere favorable to research.

While the actual number of degrees granted by these institutions represents only 13.5% (78 of the 571 degrees), the number of institutions professing to offer the doctoral degree in which the research atmosphere is unsatisfactory is quite large. In fact, from the replies received, a total of 65 institutions indicated that they offered the doctoral degree in one or more areas of engineering. Of these 65 institutions only 38 or 58.5% fell in the category of maintaining a research atmosphere which is conducive to long-term basic research, whereas 27 of the institutions or 41.5% were in the unsatisfactory or only passive research support area. While the better research atmosphere institutions are able to handle the present load of Ph.D. candidates, it is probable that this condition will not exist in the near future when the number of Ph.D. candidates will increase. It therefore becomes increasingly important that more institutions in categories (B) and (C) as indicated in Table I improve their situation so that they can offer the doctoral degree under satisfactory research conditions.

It is therefore evident from the answers to question one, "What is your official policy relative to staff loads and time allocation for staff research?", that there is high correlation between a satisfactory research atmosphere and the number of Ph.D. degrees granted. The 24 institutions in which the support of research was greatest and in which the research atmosphere was best, granted over 70% of the doctoral degrees. If the additional 14 institutions are included whose research atmosphere is good, the total percentage of doctoral degrees granted under reasonably satisfactory conditions exceeds 86%.

While less than 14% of the degrees granted were at institutions where the research atmosphere and research support were unsatisfactory, this represented 27 of the doctoral degree-granting institutions or 41.5% of the number of institutions. This situation needs careful attention for its future implication. It is essential that more universities recognize that they have an obligation to support research as well as to teach undergraduate courses.

Type of Research

The second question asked was "Do you believe that both 'applied' and 'basic or fundamental' research should be conducted in your college? Do you have an opinion as to the relative percentages of the two types that you would like to see in your institution? How near are you to that goal?" As might be expected, there was considerable difference of opinion on the specific definitions of "applied" and "basic or fundamental" research. In order not to cloud the issue on the answers to this question, each person was asked to answer the question in the light of his own definition of applied and basic or fundamental research. Therefore, the standards for the answer may vary somewhat from institution to institution.

There was almost unanimous agreement, regardless of definition, that an engineering college should do both "applied" and "basic or fundamental" research in the engineering sciences. The only exceptions were some of the group (A) institutions (see Table I) which either had no opinion on research or did not believe that any research should be conducted in the engineering college. On the other end of the spectrum one of the Group E institutions stated that the research should be 100% "basic or fundamental" research.

The preferred percentage of basic research varied from 20 to 90% with an average value of 55%. However, the value of 50% appeared more frequently than other percentages. (See Table III.) The desirable split at any one institution will depend on the interests of the individual staff members.

The answers were tabulated in accordance with the type institutions (Types A, B, C, D, and E), to see if there was a significant trend in the percentages favored depending on the research atmosphere of the institution. As shown in Table II, there does not appear to be any significant trend and it can generally be said that engineering educators believe that a significant amount of both applied and basic research in the engineering sciences should be in operation in the various engineering colleges throughout the country. The reasons given varied considerably but the one mentioned more than any other is the fact that engineering is in effect an applied science. While there was agreement that advances in engineering in the future will be stifled unless more basic research in the engineering sciences is conducted, there was also agreement that basic research must not be done to the exclusion of applied research. The students in the engineering colleges should come in contact with the philosophy of both types of research. The relative ratios of the two which are in operation at any particular institution at a specific time will depend on a variety of factors such as the interest of the staff members, the nature of the problems in which the staff is interested and the location of the institution with respect to

TABLE III

DESIRABILITY OF BOTH APPLIED AND BASIC RESEARCH IN THE ENGINEERING SCIENCES AT UNIVERSITIES

Type Institution	Number of Institutions	% Applied	% Basic
Average of all answers	139	45	55
Type E	26	40	60
Type D	29	48	52
Type C	39	43	57
Type B	31	48	52
Type A	14	42	58

types of industry and natural resources of the area.

Except for institutions in the Type E classification, there was general agreement that more applied research was now in operation in the universities than appeared desirable. The general reason given was that money for the support of applied research was much easier to obtain and, therefore, it was better to do the applied research than no research at all. The deviation from the goal of approximately 55% basic research and 45% applied research in the engineering sciences varies widely and is greatest in those institutions which do not offer the Ph.D. degree.

Staff Availability

The third question asked was as follows:

"Approximately how many members of your present staff would be interested in conducting 'basic' research in one of the engineering sciences if funds from a National Science Foundation grant or other source were available? (Indicate separately staff members not now engaged in research for lack of funds and those who might drop 'applied' research in favor of basic research if funds are available.)"

In considering the answers given to the first part of this question, that is those staff members now engaged in research for lack of funds, the answers fell into two general categories: (a) those who were doing comparatively little or no research largely for lack of funds or inability on the part of the institution to allow time for research without outside funds, and (b) those staff members who were doing a moderate amount of research, but who could do further basic research without overloading themselves. In order to obtain a proper perspective, the availability of persons should be considered in relation to the institution by whom they were employed.

In the B and C Type institutions, most of those who would like to do basic research and were not doing it, gave the prime reason as lack of funds. In the D and E Type institutions, more staff members usually had some research support but indicated that they could conduct additional research without an undue overload if funds were available. One other point should be stressed and that is the uneven distribution of research funds by the various disciplines within the engineering sciences. The number of staff members immediately available for basic research if grant support were available is quite limited in the fields of electronics, metallurgy and aeronautics. These are the three fields in which the major concentration of funds has come from the Department of Defense. On the other hand, there has been much less emphasis from the Department of Defense on basic research in the fields of chemical engineering, civil engineering and mechanical engineering. Therefore, there is available immediately a larger number of staff members in these areas.

Table IV summarizes the availability of persons to do basic research by types of institutions in which they are employed.

The second part of the question, asking about, "those who might drop 'applied research' in favor of basic research if funds were available," shows a somewhat different pattern. From the answers to this question, it is evident that while

TABLE IV

STAFF MEMBERS IMMEDIATELY AVAILABLE FOR BASIC RESEARCH IN THE ENGINEERING SCIENCES IF GRANT SUPPORT IS AVAILABLE

Institutions			Research Staff Available	
Type Institution	Number	Per Cent	Number of Men	Per Cent
A	14	10.1	4	0.9
B	31	22.3	58	13.0
C	39	28.1	117	26.3
D	29	20.8	87	19.5
E	26	18.7	177	40.3
Total	139	100.0	443	100.0

many staff members are kept busy with as heavy a research load as they can handle, these staff members are not entirely happy with the type of research support which they have been receiving. While many of these research programs intend to be of the basic type, the mere fact that support is coming from an agency which has a specific mission to accomplish, other than the research, tends to slant the direction which the research takes.

In comparing Table V with Table IV, as might be expected, a rather substantial number of persons now doing research and employed in Type E institutions would like to shift their research more towards the basic end of the spectrum. They would prefer that support would come from a source that had research as its primary aim, so that there would be less tendency to slant the program toward a specific objective.

One other fact seems to be evident from the answers to this question. If the B and C Type institutions are to engage in a comprehensive research program, they must acquire a larger number of staff members who would be interested in doing basic research. For example, from Table V, the Type E institutions represent only 18.7% of the engineering institutions, but they have on their staff 43.3% of the persons who are interested in doing basic research, whereas the B Type institutions represent 22.3% of the total engineering institutions but have on their staffs only 13.6% of the persons who are interested in doing basic research. Contrary to expectations this discrepancy cannot be explained on the basis of student load either at the graduate or undergraduate level. The 31 B type institutions have an average of about 900 undergraduate students and 145 graduate students, whereas the 26 E type have an average of 1300 undergraduate and 260 graduate students. The research atmosphere at an institution can be fostered by a sympathetic administration and careful selection of staff. This is possible despite higher than desirable teaching loads.

TABLE V

TOTAL STAFF MEMBERS WHO WOULD PREFER TO DO BASIC RESEARCH IN THE ENGINEERING SCIENCES IF GRANT SUPPORT WERE AVAILABLE

Institutions			Research Personnel	
Type Institution	Number	Per Cent	Number of Men	Per Cent
A	14	10.1	43	2.2
B	31	22.3	266	13.6
C	39	28.1	409	20.9
D	29	20.8	390	20.0
E	26	18.7	846	43.3
Total	139	100.0	1954	100.00

As a check on the validity of the figures in Tables IV and V, an estimate by a different procedure has been made of the number of staff members who might do basic research. It is estimated that there are about 9000 * engineering educators in the United States. On the average staff about 50% will be interested in doing research of any kind. Of those interested in engaging in research, 55% (see Table III) will be interested in basic research at any one time. This would indicate that about 2500 staff members in engineering might need support for basic research. Almost 2000 of these persons have been located (see Table V). The additional persons are at the eight accredited institutions which did not reply to this survey and at the 45 institutions offering engineering but whose undergraduate courses are not accredited.

Graduate Students

The next question was worded as follows: "Since the manpower situation is quite serious, in regard to engineering students with advanced degrees, how many new graduate students, either at the M.S. level or the Ph.D. level, could be supported and encouraged to obtain their

* Educational Directory, The University of Chicago Press, January 15, 1953.

advanced degrees through the research mentioned above?"

As might be expected from the answers to the previous questions, there was some variation due to the type of institutions. The type A institutions had little interest in graduate work and would provide few additional graduate students. The number of additional graduate students that could be supported is almost directly proportional to the staff members interested in research at all the other institutions. While there was some tendency for the institutions of the (D) and (E) types to handle a slightly larger number of graduate students per staff member than at the (B) and (C) types, the number is probably not statistically meaningful. For all practical purposes it can be said that on the average there would be 1.5 additional graduate students per staff member who received grant support for basic research.

Therefore, somewhat more than 600 additional graduate students could be trained immediately by the somewhat more than 400 staff members who are presently available to do basic research. If other staff members could be relieved of a portion of their applied research and were given support to do basic research, more than 2700 additional graduate students could have their research supervised by the 1900-odd staff members who would become available.

TABLE VI

ADDITIONAL GRADUATE STUDENTS WHO COULD BE SUPPORTED BY GRANTS

Type Institution	Staff Available Immediately	Graduate Students Immediately	Future Staff Available*	Future Graduate Students*
A	4	4	43	43
B	58	58	266	266
C	117	164	409	573
D	87	128	390	574
E	177	273	846	1311
Total	443	627	1954	2767

* These columns are based on the assumption that staff now engaged on applied research could replace part of that support with basic research support.

TABLE VII

TYPICAL GRANT

(Items in order of importance to the institution)

Item	
1. Staff Salary (mainly summers)	$1600
2. Graduate Assistants (1½)	3300
3. Permanent Equipment	1000
4. Expendable Equipment, Supplies, Travel, etc.	1000
5. Indirect costs @15% of total (approx.)	1000
Total	$7900

During the year 1951–52 the 149 institutions having one or more curricula accredited by the E.C.P.D. conferred 27,155 * bachelors or first degrees. At the same time there were conferred 4132 masters degrees and 586 doctors degrees.

The consensus of opinion of those to whom the author has raised the question is that there is need for 20 masters degree and 5 doctors degree people for each 100 bachelors degrees in engineering subjects. If this is true, then the graduate schools are supplying only 80% of the masters degree people and less than 50% of the doctors degree people needed on the basis of the present graduating classes.

If *2700* graduate students were supported by the research grant program mentioned above, a big step forward would be taken towards filling the gap. When students are supported by grants, they can expect to earn the masters degree in from 1 calendar year to 15 months, whereas, at the present time, the enrollment of 17,418 graduate students produces only 4132 masters degrees per year, or almost 4 years to earn a masters degree. This is due to the fact that the majority of the graduate students are enrolled in night courses and are employed full-time † during the day. Thus

* J. Eng. E. *43*, 4 (1953).

† Op. cit.

they can do only a limited amount of graduate study each year.

On the assumption that a 1-year grant will produce 1 masters degree, a 3-year grant will produce 1 doctors degree and that a ratio of masters degrees to doctors degrees of 4 to 1 is desirable, the research program mentioned above could produce 1500 persons with masters degrees per year and 400 persons with doctors degrees per year. This would be the annual increase per year and would go a long way towards filling the needs.

Research Support

Having now determined the needs for staff support of basic research and the number of additional advanced degree engineers that could be produced, the next question was directed towards the cost of the program. The fifth question asked was, "In round numbers, how much additional money (above that presently available to you) is needed to support such a research program at your institution? In making your estimates on this matter, it is assumed that in order to activate the program, you would not hire additional staff members other than technical assistants or the graduate students mentioned above. It could be assumed that the grant might support, during the summer months, those members of the staff who are on a nine or ten months basis so that the research program could have continuity."

The replies to this question were surprisingly consistent with the variations predictable on the type of the institutions (A, B, C, D, or E as noted in Table I). There is almost unaminous agreement that the first and most pressing need is for the payment of staff salaries during the summer months. Many staff members would like to do basic research but the necessity to earn additional income during the summer forces them to either (a) take off-campus employment during the summer months or (b) do applied research on campus.

Only the D and E type institutions are able to give the staff low enough teaching loads so that basic research can be done during the academic year without charging a portion of the principal investigator's salary to the grant. The C type institutions, in limited cases, may be able to allow the staff time for basic research but in most cases must charge a proportionate share of the principal investigator's salary to the grant in order to hire additional personnel to carry the teaching load.

The second greatest need for support on the grant is assistance to the principal investigator in the form of graduate students. Most of the institutions had unfilled graduate assistantships of various types which could not be filled because the salary was too low. There was unanimity of opinion that more graduate students could be obtained by raising the value of graduate research assistantships, but there was considerable variation of opinion on the amount.

The best estimate of the needs to encourage the required number of graduate students in engineering is based on a series of discussions coupled with the formal answers to the questions. It is based on the fact that (a) the ratio of earnings of the new bachelors degree man to his earnings as a graduate assistant must approximate the ratio that existed just prior to World War II and (b) the amount that the graduate student receives on a 12 months basis this year should equal in purchasing power the amount that he would have received at that time. These two lines of reasoning equate to a minimum 12 months pay for a graduate research assistant as varying from $2000 to $2400.

Using these figures as a base and adding the fact that the student would be working on a research problem that would be acceptable to the graduate school for degree purposes, there is overwhelming agreement that the desired number of qualified graduate students could be obtained in the various day school graduate curricula. The average grant request

would be for support of one and a half such graduate students.

The item mentioned as third in importance was permanent equipment. On the average that amounted to $1000 per grant per year.

The fourth item is a catch-all covering expendable equipment, supplies, travel and other miscellaneous items. These totalled about $1000.

When the items are totalled and 15% is added for indirect costs the amount is approximately $8000 per grant per year. (See Table VII for breakdown.)

From this analysis it now appears reasonable to state two figures for the support of basic research in the engineering sciences.

The first figure is an amount that is needed for the support of basic research immediately. It would go to the support of the approximately 437 staff members (see Table IV) who do not have research support at this time. If each of these persons was to receive the average grant of $8000, the total needed for the basic research support in the engineering sciences is $3,500,000. This sum is predicated on the fact that there would be no reduction in research support by other agencies, either governmental or industrial.

If there were a reduction in applied research support and support were given to all the engineering staff members who would like to do basic research, the number is approximately 2000 people (Table V figure accounts for 1954) requiring $16,000,000. This figure is predicated on allowing 1 average grant for each person capable of doing basic research in the engineering sciences with the universities supplying all the additional funds from their normal sources.

Summary

The most striking factor which this survey brings to light is that an insufficient number of engineering colleges recognize their responsibility towards research and the advancement of knowledge. A sound doctoral program is dependent on a favorable research climate. Over 40% of the Ph.D. degree granting institutions had insufficient funds to justify such a program without resorting to staff overloads or contract research support for the staff.

Research in engineering colleges should be divided between basic and applied research. A ratio of approximately one to one in the two types appears to be the most desirable situation.

In order to assist more staff members to do basic research, funds are needed to pay additional staff salaries during the summer months. This requires a sum equal to about 25% of the present academic salary for those persons.

To increase the number of graduate students in engineering, funds must be available. It is estimated that between $2000 and $2400 per graduate student is needed for their support. On the basis of staff members now on the staffs of the universities, about 2700 additional graduate students could be educated with present facilities.

On The Role of Physics in Engineering Education?

By R. J. SEEGER

Assistant Director, National Science Foundation

Since the organization of the American Society for Engineering Education in 1893, there have been many studies of engineering curricula, such as the Mann Report (Carnegie Bulletin No. 11), the Wickenden Report of 1923 (said to be "monumental"), the "Aims and Scope of Engineering Curricula" (1940), "Engineering Education after the War" (1944), and Jackson's "Present Status and Trends of Engineering Education in the United States" (1939, essentially a "supplement to the Wickenden Report").

The present ASEE Committee on Evaluation of Engineering Education proposed 34 searching questions at its Chicago meeting in September 1952, and suggested these as items for discussion by Institutional Committees. A group of these questions dealt with the curricular content and its relation to the objectives of engineering education. Among the 53 reports submitted by Institutional Committees, there is general agreement that research in physics has been constantly expanding the available knowledge in this field and that any current revision of engineering curricula must of necessity involve consideration of the inclusion of this new material into the already overcrowded physics courses. Some provocative excerpts from these reports are cited below with respect to physics.

Provocative Excerpts

"The injection of recent scientific advances in undergraduate curricula will prompt thinking along the lines of a five-year program." "Additional mathematics and physics fundamental to particular departments must be added in the time available." New material must "be crowded into the present curriculum by reducing empiricism, by a more fundamental presentation of subject matter, and by integrated study of various fields." "Nuclear physics, some aspects of biochemistry, statistics, topology and nomography will be translated into engineering practice within 25 years. The fundamentals could conceivably be substituted for other topics now taught." "Atomic and nuclear physics should include the structure of the nucleus, radiation and its detection, nuclear fission and power, mass spectroscopy, wave motion, low temperature, high vacuum effects and ultrasonic spectroscopy." "Sophomore physics should be modified by de-emphasizing mechanics, electricity and heat, and substituting modern physics in place of these." "A vote of one engineering faculty showed 62% favoring the introduction of nuclear physics in the present undergraduate curricula." "Duplication of course content can be minimized by de-emphasizing such topics as mechanics, electricity and heat in physics." "Sophomore physics should be altered by eliminating mechanics, heat and electricity and increasing the time for light, sound and nuclear physics." "Many engineering service courses are designed for students majoring in a particular field by instructors with no interest in or knowledge of the student's background." "About 60% of one faculty voted in favor of requiring

thermodynamics, heat transfer, electrical circuits and fields, electronics, differential equations and nuclear physics for all engineers." One local committee proposes "that all of sophomore physics be deleted and taught as separate subjects in the engineering science division. These would include mechanics, thermodynamics, electricity, light and sound."

At the Gainesville meeting of the Main Committee in June 1953, two subcommittees were appointed to consider certain questions involving curricula. Excerpts from tentative drafts of their reports are given below with reference to physics.

Excerpts from Sub-Committee Reports

"Much fundamental research in what is now called the engineering sciences was then being conducted by physicists. Since 1940 nearly all research physicists have had their interests reoriented toward nuclear problems and it seems doubtful that this interest will be adequately returned to the fields of vibrations, elasticity, plasticity, heat transfer, engineering thermodynamics, fluid flow, electronics and the other background sciences of engineering. Hence *engineers have become responsible for the continued research in all the fields of engineering science.*" *"The first four years of the undergraduate program can hardly be identical any longer for these two types of engineering education which in this report will be called professional-general and professional-scientific.*" One engineer has defined engineering science as those portions of physics, chemistry, and mathematics that are no longer of interest to research physicists, chemists, and mathematicians. "The very nature of the full background is such as to call for graduate studies in the engineering sciences."

Under the curricular content recommended for *professional-scientific* accreditation one finds: "Physics—including an introduction to modern and nuclear physics and inluding that of the solid state, but excluding mechanics, electricity and heat from the elementary course if this material is adequately covered elsewhere."

Under the curricular content for *professional-general* accreditation one finds: "Physics—general physics and such topics of modern physics as may be appropriate to the curriculum, but excluding mechanics, electricity and heat if these are covered adequately elsewhere." "Past experience would lead us to predict with reasonable assurance that the new developments in atomic, nuclear, and solid state physics . . . will become the center of rapidly and developing areas of engineering practice in the years ahead."

"Physics as taught for engineers has undergone only minor changes during the past generation in which many revolutionary new concepts have been developed that are influencing engineering practice. Modern physics, including nuclear and solid state physics, should be included in undergraduate curricula. It is felt that duplication between physics and statics, dynamics, thermodynamics, and electricity should be reduced or eliminated to provide time for basic study of modern physics. The study of acoustics and optics is considered desirable rather than essential so that its consumption of time should be small."

Increase Efficiency

"There is the possibility of increasing the efficiency of instruction or of eliminating some of the existing course content. Several of the Institutional Committees have discussed the excessive duplication existing between both the material covered in mathematics, physics, and mechanics, and between the material covered in these basic courses and that covered in advanced engineering courses. It is not uncommon to hear remarks regarding the inability of students to learn the fundamentals of electricity in physics, and of their having to start all over again in electrical engineering. Similar remarks involve mechanics and mathematics, and college mathematics and high school mathematics. There is doubtless some truth in these statements but many times the problem is deeper and frequently is a result of lack

of coordination and exchange of information among departments."

"Perhaps a more serious loss in efficiency of instruction occurs because of the lack of motivation of students in the basic courses. This lack of motivation is recognized both by mathematics, physics and chemistry teachers, and by the engineering staff. It might be possible to improve this situation by inaugurating a single consolidated series of courses comprising the basic material in mathematics, physics, chemistry, mechanics and thermodynamics in the first five of six semesters. It would be taught in the engineering college to provide real motivation to the assignment of strong engineering applications. Accompanying laboratory work should consist of engineering experiments and not classical experiments in physics and chemistry. Such a series of courses should develop leadership and initiative in the students. Engineering reports, including drawings, should be prepared, and nomographic charts, elementary statistical analyses and basic measurements and measuring instruments should be studied and utilized. Since such a set of courses should require considerably less time than the conventional arrangement, it would be possible to offer advanced courses in modern physics, chemistry and mathematics in the last year of the curriculum. These courses would be taught by the staff members in the special fields. The material would then be presented to more mature students better able to appreciate the presentation by specialists in these respective fields."

"It must be emphasized again that each school should find its own solution to the problem of increased demands. The Committee feels that the added requirements can be met within the present time framework simply by increasing the efficiency of instruction and of curriculum organization. Successful professional engineers in the industrial field depend upon increased efficiency for success, and a professional engineer in education should be no exception."

Physics Committees

At its Baton Rouge meeting in February 1953, the ASEE Committee on the Evaluation of Engineering Education appointed a Physics Subcommittee consisting of E. Weber (electrical engineering, Brooklyn Polytechnic Institute), Chairman; A. P. Colburn (chemical engineering, University of Delaware); and R. J. Seeger (physics, National Science Foundation). This Subcommittee's report was adopted by the Main Committee in Gainesville in June 1953. It recommended that certain questions be referred to the ASEE Physics Division and certain other questions to the AAPT. In the ASEE Physics Division, the matter was referred to its Executive Committee consisting of R. J. Seeger (Chairman, National Science Foundation), C. E. Bennett (University of Maine), G. P. Brewington (Lawrence Institute of Technology), G. Burnham (Norwich University), J. R. Dunning (Columbia University), E. Hutchisson (Case Institute of Technology), D. H. Loughridge (Northwestern University) and J. G. Potter (A. & M. College of Texas). In the AAPT, the matter was referred to its Committee on Engineering Education: J. H. Keenan (Chairman, M.I.T.), C. E. Bennett (University of Maine), O. W. Eshbach (Northwestern University), W. C. Kelly (University of Pittsburgh) and J. G. Potter (A. & M. College of Texas). These committees met jointly with the Physics Subcommittee of the Main Committee and A. Bronwell, Secretary of ASEE, at the American Institute of Physics in October 1953.

More Widespread Discussion Needed

These committees recommended unanimously that no action be taken by the ASEE until there has been more widespread discussion of the problem among physicists and engineers. In order to insure more widespread knowledge, they recommended that an article be written for *Physics Today* to give physicists immediately some advance information about the

problems at hand. Finally, these committees recommended early institutional discussions and national symposia, as well as curricula conferences by small groups representing various points of view.

It is evident that engineers and physicists must both answer the questions: What contributions *can* physicists make to engineering education? What contributions *should* physicists make to engineering education? In short, what is the role of physics in engineering education?

College Notes

The University of Pennsylvania has announced the elevation of Dr. Carl C. Chambers, Dean of the University's Moore School of Electrical Engineering, to Vice-President in Charge of Engineering Affairs. He will direct the University's educational activities in chemical, civil, electrical, mechanical and metallurgical engineering.

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Nils Yngve Wessell was installed on December 9, 1953 as President of **Tufts College.**

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L. V. Bewley, head of the department of electrical engineering at **Lehigh University,** has been named dean of the college of engineering at that school.

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R. S. Green has been named executive director of the Engineering Experiment Station at the **Ohio State University.**

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The Eighth Annual Industry-Faculty Conference will be held at **Louisiana State University** on April 6–7, 1954. The theme for the conference will be "Education and Industry."

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Edward McHugh has been appointed dean of engineering at **Clarkson College of Technology.**

Let's Look at the Causes for the Professional Collective Bargaining Groups

By T. H. EVANS

Dean of Engineering, Colorado A. & M. College

The paper by Dean Woolrich on The Professional Engineer, in the April issue of our journal, I believe, is an unusually capable, sincere, and intelligent attempt to review the situation within our profession today. This is an effort to discuss some of the points he raised and perhaps to try to visualize more of the other side of the picture, to which the writer has devoted some study.

"Unionism" has a rather sinister connotation to many of us because of actions of the labor unions over the years. It can mean violence, lack of the public interest at times, getting all that the traffic will bear, diminution of productive effort, equating all in the union to a common level irregardless of merit. In other words, a goal of increased reward for increased mediocrity.

The word "union" also can mean something fine. Our forefathers created a Union, and for its preservation many of our fellow countrymen have died. Therefore it is not clear why we must assume that a much higher level group of professionals is bound to follow the labor union line simply because they have banded together to act collectively with their employers, or because they bear the sometimes unfortunate name, "union." It is believed to be the word alone which has apparently colored the thinking of many professional people and caused a prejudgment against these groups before they have had a chance to act in any way —either professionally or unprofessionally. It does not seem logical to assume that a professional engineer will act like a professional because be belongs to an engineering society, but like a typical labor unionist if he also belongs to a professional bargaining group. From what the writer can learn about most of these groups they have no intention of following the pattern set by the labor unions. Their objective is to deal with management on a rational, fair, cooperative, ethical, and professional level. Most of them appear to realize that they have a critical stake in the progress of industry, just as the latter should have in the welfare of engineer employees. They seem to have no intention of trying to bleed industry of all its profit. They are trying merely to get industry ot recognize the proper economic level for the engineer (and particularly the engineer with five or more years' experience behind him). Nor is there to be a "levelling off," as is typical of labor unions. These engineering associations have advocated categories within an industry depending on ability, experience, and other factors; which is similar in objective to those our national societies have published from time to time, showing different grades of engineering ability, and even advocating ranges of salary in some instances. It should be emphasized that the Engineers and Scientists of America is merely a national federation and that each member unit would still handle its own employer-employee relationships. Therefore the numbers involved would not be so great that an individual would be lost sight of. And although the basic reason for forming these groups is the feeling of a need for eco-

nomic improvement, only because the profession has not helped them in this respect, their other principal objectives are professional and social improvement for the engineering employee. Many of these same points were brought out at the ASEE meeting in June 1949.

Where there is so much smoke there must be some fire. Something is radically wrong in our profession when a group such as ESA can spring up almost overnight with a strength comparable to any one of our individual engineering societies. Many of us don't feel we can arbitrarily condemn such groups, which are fighting for individual rights, when they honestly believe they need collective help. A large number of these individuals wanted their profession to help. It could not because it was fragmented and had no real power. Nor has the recent attempt to insist on Plan A for unity, rather than a more democratic and more universally acceptable plan, helped make those already dissatisfied feel that the profession was sincerely interested in the welfare of the engineer as an individual. Until the profession could show real interest in, and intent to help, engineers in *all* aspects of their professional life, it is difficult to see how these engineers forming the bargaining units could be expected to do otherwise.

Industry Has Been Negligent

As Dean Woolrich points out, industry has obviously been negligent in setting up proper scales of advancement for engineers with several years of experience. Is industry in general going to assume the responsibility to correct these inequities? The disunited Engineering profession has been unable to do anything about it. So what is left to an individual with any backbone? When a conserative group like the engineers flares up in many localities there must be some good reason for it.

The real kernel of the difficulty may be the apparent inability of the autonomous groups making up the Engineering profession to give a little in order to bring about what is best for the whole. From comments all around the country it seems apparent that the bulk of the membership of the engineering societies are far from being preponderantly in favor of Plan A, even though it is the one now being put into effect. There is at least one Section of ASEE which is almost unanimously in favor of some plan more akin to C than A. If a democratic survey of individual professional engineers throughout the country was made (or even just among those in the societies) the great majority would apparently be in favor of Plan C, or some plan similar to it, such as that proposed by the GE Engineers Association in Electrical Engineering for April 1953.

We thus have a tug of war between certain powers in the technical societies, the NSPE, and now the ESA. One possible solution is for the rank and file of the profession to insist on immediate and truly acceptable Unity, *coupled with an additional and definite objective showing some intent to improve where necessary the economic welfare of engineering employees* based on their achievements and contributions to industry. It is believed these two moves would eliminate the basic cause of the unrest and dissatisfaction within our profession. If this were done quickly then the need for any local "bargaining" would be nullified. Many local sections of the national societies are requesting their Boards of Direction to do this.

Defense Measure

Some of us feel that the engineering collective bargaining groups are a defense measure, used in desperation when no other help was available; and if the Engineering profession was truly unified, as is the Medical profession, then it could give the employed engineer the help he presently feels only the bargaining groups can give him. The writer will be disappointed badly, and clamor as loudly for their scalps as anyone, if these groups in general lower themselves to the unethical and unprofessional tactics of the labor

unions. Since the profession is not giving adequate support to the individual professionally and economically, however, one can't honestly condemn these bargaining groups for trying to pull the iron out of the fire, if they maintain their ethical and professional standards. Naturally we must be concerned about the strength and growth of the collective bargaining movement, but if we can't offer something as good or better then it seems unreasonable to condemn such groups, especially if they prove to be truly professional. Condemnation only raises a smoke screen to cover the ineffectiveness of our profession as such. Major surgery to get at the fundamental causes of our disunity is needed, and not some expedient measure that will create further disunity. The truly scientific way is to analyze the entire problem objectively for basic causes, and it does not seem that such has been done fully. This paper is a meager attempt to try to expose a little of the other side, about which we have heard almost nothing. It is no intended as a plea for more collective bargaining units; but it is intended to stress the need for more constructive suggestions to overcome the need for such units. What we must all strive for is *real* Unity, and the time is now.

As engineering educators we have a great stake in this tug of war. We also have an opportunity to do something about it in the local sections of our national societies, and with our students.

College Notes

A short course on High Temperature Properties of Materials will be held at **The Pennsylvania State University** between June 21 to June 25 inclusive. Following this course one on Mechanics of Creep will be conducted between June 28 and July 2. Authorities from industrial, governmental and educational institutions will give the lectures for both these courses. The programs are planned to give a broad coverage of high temperature properties of materials and mechanics of creep by including physical, metallurgical and design aspects of these subjects. For further information, please write Dr. Joseph Marin, Department of Engineering Mechanics, The Pennsylvania State University, State College, Pa

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Two hundred high school science and mathematics teachers from 24 states will spend six weeks of expense-free study next summer under fellowships granted by the **General Electric Company.** The four programs will be operated at Union College, Schenectady, for 50 science teachers; Rensselaer Polytechnic Institute, Troy, N. Y., for 50 mathematics teachers; Case Institute of Technology, Cleveland, O., for 50 physics teachers; and Purdue University, Lafayette, Ind., for 50 mathematics teachers.

Teaching Tips
(A New Feature)

The fundamentals of good teaching are known to nearly all teachers. These include a good knowledge of the subject, adequate preparation for class, clear explanation, student motivation, and a sincere interest in the individual student. "Teaching Tips" are not meant to reemphasize these fundamentals, but rather to provide stimulating suggestions regarding their application to various teaching situations.

Our first "Teaching Tip" is from the Institutional Report of the University of Rochester on Improvement of Teaching. We hope it may suggest an improved technique for doing your own teaching job.

We would like to publish a series of such tips and need your help in finding and reporting them. When you have used effectively a new or different approach to your teaching, it gives a thrill! Won't you share it by sending us a report of it?

FRED H. PUMPHREY
University of Florida
Chairman, Committee on Excerpts from Institutional Reports

A Kinematics Term Report

University of Rochester

A term report in Kinematics is used at the University of Rochester to achieve the following three-fold objective; first, to relate the study of kinematics to everyday experience and to arouse the curiosity of each student; second, to develop an appreciation for the careful design that has gone into the many mechanisms he finds and uses; and third, to develop the habit of a systematic gathering of data to be used as the basis for analysis and design.

In order to obtain the time for this report, the time needed for other phases of instruction were reduced as follows:

a. Teaching films reduced the time needed for lectures.
b. Laboratory or drafting time was reduced by combining two objectives in a single problem.

This arrangement provided two weeks at the end of the course for a term report. The class time was used to review the course, outline what was wanted in the term report, and class discussions that developed from the term report. The study time (amounting to 8 hours per week) was used for writing the report, and the laboratory time (amounting to six hours per week) was used for the preparation of such drawings as were required in the report.

The students were first advised that a term report would be required at the beginning of the course. They were advised not to make a selection of the project until later in the course. At the middle of the term, they were required to select a problem (usually a linkage) on which to report.

They were encouraged to visit local in-

dustries and discuss kinematics linkage problems with them. And finally they were given definite instructions for the selection of a project, the instructor using care to prevent the student from selecting a problem that was either too simple or too complicated.

The report form used is direct. First, there is a careful description of the linkage, its purpose, and any other pertinent material. Second, there is an analysis of the motion, with a formulation (if possible) of the ideal situation. Then there is a comparison of the ideal situation with the actual solution. In this portion of the report the use of instant centers, motion curves, and mathematical relationships are included. Some consideration is also given to power economy.

The third portion of the report is a conclusion. This states how well the purpose of the mechanism is accomplished. If a comparison between various desirable features in the design is involved, the compromise is discussed.

There is always the possibility that some student may stumble onto an improvement.

Project Method is Used in Time and Motion Study Course

University of Rochester

". . . . . The class divides itself into squads of two for laboratory work and each squad works on a project of its own choice. Many of these are in no way related to any of the others but a few each term work as a group of squads in an assembly line type of accomplishment of a task. In the beginning, they make a microanalysis of the performance of the task with the aid of 16 mm movies and sino chart from which they develop a new method using the basic principles of motion and time study as well as those of mechanics, economics, and the other fields. We then open up our wood working, machine shop, electrical and related facilities for them to use as they see fit in demonstrating their ideas.

The instructor plays the part of a supervisor of so many research projects and interferes only to the extent that a good supervisor should. In addition, bull sessions of the type that broaden the base of the education of the student are promoted.

In this way, we

1. teach motion and time study.
2. integrate accomplishment in several fields.
3. develop the concept that many problems must be solved by industry at the same time, in contrast to situation where all members of a class solve the same problem at the same time.
4. provide an outlet for an engineer's desire to use his hands in a physical demonstration of his ideas.
5. help the student evaluate the magnitude of a research project.
6. promote interest in younger men by conducting this interesting work where all see it frequently."

The Final Course*

Dress Rehearsal for Practice

By A. BOYAJIAN

Consulting Engineer
(General Electric Co., retired)

The rapid growth of technology, with the increasing number of specialties, has made many of us sigh with discouragement in our efforts to keep up with the progress of the art. The older engineer has dropped, one after another, many subjects whose literature he used to scan. But schools can not afford to neglect the technical progress. The smaller schools are seriously handicapped, and while the biggest schools can maintain a specialist in each subject, adding more specialties and offering an increasing number of courses each year, yet the student's limited capacity to learn and his inability to forsee into what specialty circumstances will take him later, constitute the real handicap in the big school as well as in the little.

The remedy generally offered for this situation is to *teach fundamentals*—physics and mathematics—and let the student specialize after he goes into industry. This principle is perfectly sound, but a good principle needs also a good embodiment to make it successful. When the fundamentals are taught, it would be wise to make sure that the student will be able to apply those fundamentals. Otherwise, the 4-year college attendance may mean only the learning of engineering theory and not to receiving an engineering *training*. The purpose of this contribution therefore is to indicate (a) concrete objectives and *criteria* for this purpose, and (b) *means* to accomplish it: in other words, a bridge between theory and practice.

Problems

Let us look into the problems that the average graduate of a 4-year "fundamentals" course faces.

1. He most likely will welcome employment by a large employer. Job security is greater with the larger employers, and many of them also have training courses to fit a person into a specialty.

Over the years, these courses have been evolved to fit the technical equipment of the average graduate, and so the scheme should work pretty well, and on the whole it does. And yet our candidate, if ambitious at all, is apt to be dissatisfied with his education. No matter what the group assignment may be, he is likely to be eclipsed by one or another associate who happens to have had a course in the subject. Our man will experience also another trouble that will hurt him much more acutely in the employ of a small employer as follows.

2. The simplest looking problems that arise in practice frequently involve many specialties, including higher mathematics; and while in a large company advice can be had from many specialists, in the small company one generally has to fall back on his own resources. It is general experience that learning a new course by self-help is a very difficult thing compared with learning it in school, and our

* Presented at the Annual Meeting of ASEE, Educational Methods Division, University of Florida, June, 1953.

man is apt to bemoan that he "never had a course in that in school, period," the *period* meaning that that is enough to keep him out of that field unless he goes back to school or an employer offers him a course. This is a most regrettable state of affairs. The attitude of the "fundamentals" graduate should be this, and he should be able to justify it: "I don't know the first thing about that field, but in a few weeks I can tackle at least a minor project in that field." How can he have such self confidence? By having done it in a similar situation before.

3. Depressions are terrible things for those who lose their jobs, and in applying for one job after another, our fundamentals man may face a severe competition from others who appear better prepared. Opportunities are not lacking by any means during depressions, but in each case our man somehow is not qualified to take advantage of them. He is like the speculator who sees many bargains in stocks but has no money (or credit) to buy them. To justify the principle of the "fundamentals" system, our graduate should be capable of doing a little creative planning for himself, and to prepare himself to qualify for a profitable activity.

4. We frequently speak of a "college-trained" person. Would the word "trained" be quite correct for our man? If the college coach does no more than give lectures and written examinations to the team, is that "training" the team? Realistic practice is needed in engineering just as much as in sports. Engineering practice comes after college, except in those schools operated on the Cooperative Plan, but is it not wise, as the college days draw to their close, to make sure with some trial exercises that the graduate will know how to practice when he gets out?

5. Weak motivation is a handicap in education. The average student probably does not know into what field circumstances will force him and what courses will do him the most good. So he studies the prescribed courses to get his diploma and he may even feel that he can afford to forget a number of his courses after he graduates. If the life of a college graduate depended on mastering analytic geometry or first year electronics in two weeks by self help, he surely could do it. Through intensive study, most any one-semester course can be mastered by a graduate of average ability in a few weeks with far less motivation than that, provided that he has had some experience in that direction and really needs it for a purpose. *While still in college, the student must learn how to master a new subject outside of college.*

Realistic Practice

In the light of the foregoing comments, it may be evident that to make a well-rounded graduate of engineering fundamentals, class-room instruction must be supplemented in college, under proper guidance, by sufficient *realistic* practice; and the entire second semester of the last year may well be devoted to this in a systematic program that may be called *Introduction to Engineering Practice.* This may comprise, let us say, at least four practical projects in different fields, each requiring four to six weeks concentrated labor, including the following activities.

1. During the first week or two, the student must study intensively by himself (consulting any one he wishes) the theory of the field of his project—electronics, hydraulics, communication, air-conditioning, illumination, etc. To make this speed possible, a project must open with an orientation lecture (of probably two hours) giving the student an idea of the things that the project involves, and a carefully selected list of the most helpful books and other references to study. The student must be carefully protected from bibliographies that are burdened with heterogenous, irrelevant and unintelligible items. Good books are so few, and good articles fewer yet. The student's time must be conserved by guiding him to the most helpful ones.

2. Then comes field surveys or laboratory experiments to secure the data on which he will base his decisions. For instance, if the project is the design of an air-conditioning system for a particular hospital, a survey of that hospital's needs has to be made. (Of course the original architect's drawings will fill most of the survey needs in such a case.)

3. Specifications of the necessary equipment and installations to do the job.

4. A cost estimate.

Items 2, 3 and 4 will be incorporated in a report as to a client. Item 1 may be made the subject of a written examination and carry credit for an introductory—one semester—course in that subject.

Factors Toward Success

The following factors would be of great help towards the success of such a course.

The engineering library must be adequately equipped with the most helpful books in all the fields that are likely to be encountered, including the best basic theory books, the standard handbooks and cost books, catalogs, etc. This does not necessarily imply a very large library, but it does imply a resourceful, competent and efficient library service with an up-to-date basic collection, and geared to promptly buy, borrow or otherwise secure what is needed and lacking at the moment.

2. Alumni can be very helpful in the shaping up of such a program. (a) They can suggest projects, for which perhaps they can also offer some facilities; (b) make helpful hints on how to go about these projects; (c) and serve as critics on the final reports.

It would be desirable that the school keep up a list of a dozen or more projects for the students to select from. Such a list would mean that (a) the literature of the field of the project is reasonably well covered in the engineering library, (b) catalogs and other supply information are available, (c) and a real application is available for the project. A project suggested by a student, if reasonable, may be given preference.

3. Non-engineering drudgery, such as typing, should be reduced to a minimum, resorting to paid help if necessary. All padding—characteristic of student theses—should be eliminated from these reports.

4. Both competition and cooperation may be fostered among the students. They may cooperate on a survey to save time. Also civil engineers may tackle one aspect of a project (say the bridge part of a lift-bridge), and the electricals and mechanicals another (the lift equipment). After a cooperative survey, the students may compete on the practical solution of the problem, both cost and performance being considered.

5. Invention is a very appropriate project in such a course, but it must be an elective since it requires special talent. If elected, a working model must of course be produced.

A project will have a major subject of study but may also have one or more secondary subjects for collateral study. Invention and development, and some other projects too, could be made an opportunity for learning drafting practice, without appropriating special time for it. Those who do the minimum drafting necessary for their project, will have learned enough drafting for most purposes, while those who enjoy it and do a great deal of it, may be given special credit for it.

Graduate Program in Engineering at the U. S. Naval Ordnance Plant in Indianapolis, Indiana*

By W. E. HOWLAND, *Professor of Sanitary Engineering*

and

G. A. HAWKINS, *Dean of Engineering, Purdue University*

Need for Graduate Instruction in Industrial Centers of Indiana

Purdue University offers formal academic engineering instruction to college graduates not only on the main campus at Lafayette in west central Indiana but also at three large urban centers: at Hammond in the northwest, at Fort Wayne in the northeast and at Indianapolis in the central part of the state. We have long had a large engineering undergraduate program going on at these centers but until last year the graduate programs consisted mainly of isolated courses or pairs of courses in specialized subjects of industrial importance and of refresher courses given in preparation for the engineer's training examinations. These courses rarely led to a graduate degree. There have been a number of requests for a formal off-campus master's level program of one sort or another. In Fort Wayne the demand centers on electrical engineering, especially electronics, but in other areas, although the total number of requests is significant, the numbers in any one conventional division of mechanical, electrical, civil, chemical engineering, etc., have seemed, hitherto, to be too small to warrant the setting up of a complete program. This appeared to be true at the U. S. Naval Ordnance Plant at Indianapolis which in November, 1950 requested that the University offer a curriculum of graduate instruction for their employees. Partly for this reason the type of program chosen for this, our first off-campus master's level program, was an integrated one —a definite attempt to bring together a coordinated group of courses at the graduate level that would be of value to mechanical *and* electrical and even to civil and perhaps also to chemical engineers.

Objectives of the Program

A more important reason for the integrated program was, in the eyes of the committee, charged with the responsibility for formulating the details of the courses of the program, that coordination of engineering knowledge and methods at the master's level is, in itself, worthwhile. At the very start of our deliberations we wrote as follows:

> It is recognized that some specialization is absolutely necessary, no one mind being large enough to contain all the facts to say nothing of understanding their relations in even one field of modern knowledge, like engineering. There are those who ascribe the great progress of technology to this very specialization. But this tendency has reached, some feel, a point of diminishing returns and the need has now arisen, especially in engineering, for more men whose range of understanding covers at least the main methods of thinking that have been developed in the so-called basic engineering sciences. We need specialists it is true but we need specialists who know enough about their associates' specialties so that they can put their questions to them and understand the answers and, in general, effectively co-

* Presented at the Annual Meeting of the American Society for Engineering Education, June, 1953, Gainesville, Florida.

operate with them as teams to solve practical problems which are almost certain to require the knowledge of many specialists. To meet this need, to broaden the scientific understanding of the specialists, this particular experimental curriculum has been devised.

And we believe that a specialist so trained will not only be better able to cooperate with his associates but because he has a better understanding of the fundamental laws, principles, and tools of engineering from learning of their applications in related fields he will be able to do a better job in his own field. What he misses in detailed information he will gain in intellectual range and power.†

Thus the key word to describe the purpose of the new curriculum is "integration"—the making of a whole out of an infinitude of infinitesimal parts. The parts are the innumerable facts that the student accumulates in the course of his reading and schooling, and working; the whole is the supporting of those facts on the skeleton framework of the fundamental laws and principles of engineering science with the vital connective tissue of mathematics and then their control through a sort of central nervous system that we call "mode of analysis."

In the courses that we have planned we have emphasized the similarities of some of the basic phenomena and methods of the engineering sciences. We hope to teach how a method of computation of currents and voltage drops in an electric circuit may be used in the evaluation of an hydraulic or thermodynamic or even in an acoustic circuit and why the solution of a differential equation that happens to apply to a problem in torsional stress distribution also explains the slope of the deformed membrane over an opening identical in shape to the cross section of the shaft, thus forming the basis of an experimental technique for stress study, —the so-called membrane analogy. When our students have learned in heat transfer how to determine the way the temperature changes in a flat plate as it loses heat at one central point they may be able immediately to apply this method of solution to the problem of falling water levels in the aquifer around a well being pumped. In other words, we made a deliberate effort to extend the use of our methods of analysis to many fields. We have tried to sharpen up these methods as tools that would cut into many kinds of material.

Adopted Courses of the Curriculum

Our present program for accomplishing this objective consists of four courses of mathematics called "Advanced Engineering Mathematics I & II," covering Reddick and Miller and part of Churchill's "Operational Methods," then Applied Complex Variables and Vector Analysis. Next comes a course in Selection of Materials for Engineering Structures, followed by Analysis of Deformable and Non-Deformable Systems, the Thermodynamic Mode of Analysis, Thermal Circuits, Fluid Circuits, Theory of Fields and Circuits (a 9 hour course) and Human Phases of an Engineering System. The final integrating course is called Analysis and Synthesis of Engineering Systems, in which the real practical engineering problem that involves many engineering sciences will be attacked.

How the Plan Was Evolved

A word about the way in which the plan was evolved: Dr. K. L. Nielsen, Chairman of the Professional Development Committee of the U. S. Naval Ordnance Plant at Indianapolis, initiated the inquiry to the University and, with his colleagues, met occasionally with the University committee while they were formulating the curriculum. This committee appointed by Dean A. A. Potter and headed by Dr. G. A. Hawkins met once each week for one academic year to decide upon the basic policies and then to work out the details of the plan. Dean L. M. K. Boelter served as consultant to the committee.

† Graduate Engineering Program at U. S. Naval Ordnance Plant, Indianapolis, Indiana, Report No. 1, History and General Considerations, by W. E. Howland and G. A. Hawkins, pp. 4–5.

The individual members of the committee were asked to devote their especial attention to the courses which presented the material in which they were especially trained: to study the subject matter available in the textbooks, to consider appropriate methods of presentation, to illustrate these methods before the committee, to present the modes of analysis, to outline the course material, both in preliminary and in completed form, and as far as time permitted, to prepare supplementary material needed for instruction, especially that which was not already available in the textbooks.

The first thing our committee did was to formulate what we called the modes of analysis that we employ in our several fields of engineering sciences to determine, if possible, a general pattern that is common to them all. In this venture we were successful. The pattern is common to all of the fields of engineering and to all of the kinds of problems that engineers as engineers are expected to solve. And—we personally believe—that it applies to all fields in which problems can be solved.

However, we confined our attention to the professional phases of engineering and deliberately and intentionally omitted fringe activities. (In medicine the care and cure of the human body is generally recognized as the core of the practice of medicine rather than financing medical care, hospital management, bill collecting, or the distribution and sale of medical products; ability to cure defines the physician. So in engineering, the non-specific professional activities, however important, should not, we thought, be allowed to obscure the essential problem-solving nature of the practice of this profession.)

General Discussion of the Courses Studied

Perhaps the most distinctive features of our curriculum is the emphasis it places upon the general mode of analysis. This is a topic that will be discussed at another session of this conference in a paper of that title by L. M. K. Boelter and G. A. Hawkins; consequently, it may be sufficient to state here merely that this most effective procedure for using the intellect is applicable, we believe—in a slightly more generalized form to all types of engineering problems. Perhaps we should say that we believe the general mode of analysis is an essential part of what has often been called the scientific method and that the scientific method so strengthened is widely applicable to engineering problems. In particular, it provides an effective procedure for solving the three types of problems that engineers most frequently encounter: (1) the prediction of performance of structures, machines, processes, circuits or organizations, (2) their design or planning and (3) the explanation of observed phenomena as encountered in their operation.‡

The method slightly generalized thus helps to find answers to the questions: "What will happen?", "How to make it happen?", and "Why did it happen?" As applied to the great area of human values it may also help the engineer to decide "What should happen?" If so, it would help powerfully to integrate the entire realm of organized knowledge for effective use by the engineer. This glorious but distant goal of engineering education our committee has not lost sight of and our inclusion of a course called "Human Phases of an Engineering System" bears evidence of our broader aims.

Results of the Plan of Study

It is undoubtedly too early to attempt an appraisal of the curriculum set forth in this paper. The mathematics courses have been given to one group of students but, beyond these, only two other courses

‡ Note: A detailed presentation of the more generalized method for dealing with all three types of problems and the consideration of the entire engineering curriculum as a "Preparation in Method for Explanation, Prediction and Design" is contained in Report No. 2, Development of the Graduate Engineering Program at the U. S. Naval Ordnance Plant, Indianapolis, Indiana, by W. E. Howland and G. A. Hawkins.

have been taught: Selection of Materials for Engineering Structures, and Analysis of Non-Deformable and Deformable Bodies. From teaching the latter course the indications are that the sights of the curriculum makers were set a little too high (nearer the doctor's than the master's level)—that the mathematical ability and interest in the abstract phases of engineering analysis of the older engineering graduates at work in industry are no higher and are perhaps somewhat lower than of the younger graduate students we encounter on the campus. Consequently, it is probable that modification will be made in the original course outlines in the direction of simplification and rearrangement of the material of the mathematical courses (1) to give greater emphasis to those topics that are essential to the methods employed for the solution of problems in other courses, and (2) to postpone some of the instruction in mathematics to a later time in the program, thus effecting a closer integration of subject matter, in line with the stated objectives of the curriculum. It is possible that the superior understanding of the physical phenomena by these more mature students will permit a greater elaboration and enrichment of the instruction in the nature of the phenomena than had originally been thought possible. The program will still be definitely of a master's level or a little higher.

In any case it is almost certain that modifications should and will be made. Good curricula like good laws cannot be merely enacted—they must grow!

Conclusion

This curriculum follows what appears to be a modern trend of "integration" which has manifested itself in the whole field of education as well as in engineering education. But in a real sense we are pioneering. We are proposing to abandon conventional subject matter boundaries, to reshuffle the deck of engineering facts in a new way and to play the game according to somewhat different rules. Instead of constructing a master's degree program so as to proceed further into a particular specialty from the base of previous training, we are proposing to broaden and to strengthen the foundation itself. Thus, we hope to help our students erect a deeper and stronger structure of knowledge on which eventually an even higher and certainly a stronger one will be erected than would otherwise be possible.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Physics for the Civil Engineer*

By N. W. DOUGHERTY

Dean of Engineering, The University of Tennessee

Introductory

There has been little change in the beginning course in physics during the last forty years. This may be good or it may be bad, depending upon the possible additions of new subject matter in the field of physics and changes in other, and parallel, courses in engineering. Statics, dynamics, heat, light, sound and the elements of electricity were the major topics studied during the first decade of the century, and these same topics are being taught in about the same way at the present time. Laboratory equipment is usually better, textbooks contain more illustrations, but, because of the number of students and the elementary nature of the subject, the teachers of engineers are not always the most experienced and best prepared staff members of the department.

If the philosophy of physics remains the same, and if engineers need to study the same subject matter as they did forty years ago, there is good reason for little change. Most of the subject matter in the beginning course was developed long before 1900. Sound, heat, light and electricity have passed beyond the elementary stage and have already reached maturity enough for the physicists to think of them as advanced physics. Teachers in engineering have developed volumes on mechanics, fluid mechanics, thermodynamics and elements of electricity; these works should have completely changed the picture in physics, but little change has come about.

Parallel Growth of Civil Engineering

Civil engineering programs, during the last one hundred years, have depended upon physics to give instruction in statics, dynamics, heat, light, sound and elements of electricity. This was especially true during the second fifty years of the last century. Indeed, there was a comradeship of the civil engineer and the physicist as they battled for a place in the college curriculum; they jointly pushed out languages, literature, philosophy, religion and a resistance to science and technology, and put a certain amount of utility into college curricula. Physics, chemistry, the biological sciences and technology changed the attitude of educators toward college education.

During the early development of civil engineering, and all engineering, for that matter, the courses were descriptive. They described methods of doing things, how to build machines, structures, railroads and factories and spent little time on the theory behind the building. Physics furnished the theory they needed. Mahan's "Civil Engineering," first published in 1846, was continued as a text for fifty years. Even in his chapters on structures and bridges, he does not give a single calculation of stresses in the members. He describes tests of models, and gives methods of selecting compression and tension members, but he does not introduce the elements of mechanics. If the student studying civil engineering during this period, needed a knowledge of mechanics he had to depend upon his physics for that knowledge.

The "Municipal and Sanitary Engineers' Handbook," by Bulnois, the third edition of which was published in 1898,

*Presented at the Annual Meeting of ASEE, Physics Division, University of Florida, June, 1953.

gives descriptions of the construction of roads, streets, sewers and buildings, but does not use any mechanics for sizes or thicknesses or any hydraulics for sizes of pipes or sewers. Again, if the student needed any mechanics of solids or fluids, he had to depend upon his course in physics.

Loads were increased, new materials were introduced; sizes must be computed rather than determined by rule of thumb. The civil engineer needed more knowledge of mechanics and fluid flow than he was getting in the physics courses; consequently, he wrote his own books in these fields. New materials, new methods of construction and economy measures caused him to develop the mechanics of elasticity in order that he might build rigid frames, continuous bridges, skyscrapers, concrete structures and pavements. Elementary physics no longer served his needs; yet he continued it in his educational program with the knowledge that he would repeat practically all the subject matter in statics, dynamics, and fluid flow, and that he would ask the mechanicals to teach heat in a course in thermodynamics, and he would ask the electricals to teach the elements of electricity. He needed more theory in all these areas than he was getting in elementary physics.

By this time, other engineering departments were looking at physics with a critical eye. Either they were expecting too much, and not allowing enough time, or the physics department was out of step with the needs of engineering.

During the last twelve years, we have made two major studies of the courses in physics required of all engineering students. Each time the committee has been made up of representatives of the engineering departments and members of the physics staff. They come back with a majority and a minority report. Engineering faculty members suggest fewer topics and more time on each topic; the physics teachers ask for more time to teach all the topics well. It seems obvious that a major operation is needed to solve the problem.

Major Criticisms

Out of the two studies, and from conversations with engineering faculty members it appears that there are at least two major criticisms:

1. There is an effort to cover too many topics—too much subject matter, and
2. The approach is not in the attitude and spirit of the engineer

To say that there is an effort to cover too much subject matter is but to state a fact on which all will agree, but the same may be said of all the engineering courses. One of the greatest faults of engineering programs of today is the effort to cover too much subject matter. Teachers are assigning so many pages that they have forgotten that the objective of college is learning and not intellectual drudgery. During the last three hundred years, physicists have developed so much interesting and useful material that they can spend four years on a major as preparation for graduate work. Obviously, their review of the field for engineers cannot be very deep. Let us forget about trying to cover the field and try to develop an ability in the student to work under his own steam. If he ever discovers how to learn, he will be able to acquire knowledge, as needed, during a career of useful work. Few of those who are advancing knowledge today learned all they needed to know while they were in college.

That the physicist's approach is not that of the engineer does not worry me too much, provided students get the approach of the physicist. If the courses must be likened to the circus, where the spectator views the topics and may not recognize them the next time he sees them, there is, as Governor Dewey put it, "time for a change." Engineering faculty members do not help the physics department by telling their students they have had this in physics, but will have to learn it over again. There may be questions of units and lists of names; there may be a theoretical and a practical approach, but the real problem has not been touched.

Suggested Solution

We are all fighting for time. Each decade, yes, each year, brings new ideas to develop and new techniques to master. We do not have enough time to teach everything. We add a new topic, but do not take anything out; we must find an answer to an impossible situation. The answer is not five or six year programs, but more efficient use of the time in four years.

Why duplicate the teaching of statics, dynamics, fluid mechanics, heat and electricity? The physics course will not give enough instruction in these topics, and the engineers will do it over again. Let the engineers take the topics over and teach them as they please. Give the physics department at least as much time as it now has and ask it to teach something the faculty members know and wish to teach. Their research is not in the fields just named; they are out on the borderline of knowledge, looking for new things rather than poring over things their grandfathers knew. New applications of the laws of physics are constantly in the making; engineers have this task; consequently, they are doing research in methods, in new applications and new statements of old laws. Let them teach the things they know.

Engineers need to know more about light, sound and nucleonics. Immediately we hear that nucleonics cannot be taught as a beginning course. This may be true, but who is suggesting it as a beginning course? If the time devoted to physics were delayed a semester, the engineering student will have more mathematics than for the present course, and he will have had more statics, dynamics and fluid mechanics than the physics major, who does take courses in nucleonics. Indeed, it is possible to arrange the sequences in such a way that engineers will be better prepared for advanced physics than they are now. They are lost in a wilderness of many things.

This country has been fortunate in its pioneers. Wherever there were barriers to expansion or progress there have been pioneers who surmounted the barriers and opened up new lands and new vistas. No one has felt that these pioneers are the only persons who know how to occupy the land after it has been opened up. Another kind of pioneer has followed the trails, has consolidated the gains, built up the cities, the industries and the universities.

The pioneers in mechanics, heat, light and electricity were usually physicists, though recent developments in these fields have been by engineers and in engineering laboratories. Traditionally, we have asked the people in physics to give the beginning instruction, largely because their ancestry developed the materials. Now that engineers have also entered the fields of mechanics, hydraulics, heat and electricity, and are making contributions to these fields, there is no good reason why they should not occupy the land.

Conclusions

We have pointed to the parallel growth of civil engineering teaching and physics teaching; we have mentioned the early dependence of civil engineers on physics for the scientific approach. The interests of teachers of physics have turned from mechanics and hydraulics to modern physics and nucleonics; engineers have taken up the baton of mechanics and fluid mechanics and are adding to methods and techniques. Let us drop mechanics, fluid flow, heat and electricity from the physics program and place the responsibility for these subjects on the engineers.

With the time now devoted to elementary physics, the physics department could give better courses in light and sound and add an elementary course in the field of their greatest interest, nucleonics. Instead of trying to occupy the land they discovered many years ago, they will turn it over to the developers and builders, and search out new lands which succeeding generations will occupy and develop. Civil engineers will be benefitted by the change and the physics instructor will be relieved of a task which is very difficult, if not impossible, to perform.

Books on Mathematics for Engineers and Physicists. How Can They Be Improved?

By A. F. PUCHSTEIN

Jeffrey Manufacturing Company, Columbus, Ohio

Those who use books of this type must be impressed by the differences between them and their inadequacies. The labor required to use them is out of proportion to the difficulty of the material. This is due more to the way in which it is presented than to deficiencies in mental equipment. A preferable arrangement undoubtedly exists and should be explored. But here attention will be directed more to the method of treatment than to topics that should be included. The latter would be selected from those available. These could be arranged in some orderly sequence by subjects, order of difficulty, or settled by a conference.

These books are generally written in the language and style of the mathematician. They usually assume that the user can read the text at sight, that he knows the exact meaning of all terms, symbols, and expressions; and that he can apply them without further direction. Rarely do they give tables of symbols or definitions. Sometimes no index is given. Often cross-references are few. There is little attempt at standardization. Frequently the text is closely printed in long paragraphs with makeup and topography such that the material must be read to identify it. The procedure in going from step to the next is not always given. Little use is made of the artist, draftsman, illustrator, or language expert.

Some books give the mathematics only, with and without examples. Some add examples from applied science or engineering. Some are prevailingly treatises on engineering or physics with the mathematics woven in. Some keep the mathematics and engineering separate while others do not. Frequently, different practices are found in the same book.

It seems best to keep mathematics and applications clean cut and separate., that is, to follow up the mathematics with examples of the applications placed in separate paragraphs or even in other sections of the book, and not to intermingle them in the same lines. Of course, since many of these processes are the result of trying to solve some physical problem, there exist cases where it is better to state the problem and then to outline the mathematics used in solving it. It would not hurt even to outline some problems for whose solution no mathematics are available.

Poorly Illustrated

Most books are not well illustrated nor are they always written so that the ideas, principles, operations and procedures stand out. The understanding and application of many theorems and formulas could be made more clear by numerical, analytical or physical examples. To proceed from the particular to the general is often easier to understand than is the reverse. Much greater use could be made of line and perspective drawings, sections, phantom views, half-tones, photographs, colors and pictures of models. Simple notations are to be preferred.

Too many proofs in the working parts of the text tend to obscure the substance and so are best given at the end of a chapter, book, separate volume, or left to

a reference. Also, instead of formal abstract proofs, it is often better to use the more easily understood numerical proofs. It is a question whether in books of this character proofs need be given at all. At work, it is essential to know only that the material is correct, on what assumptions it is based, what operations are permissible, conditions under which they fail, restrictions that must be observed, correct interpretations, what applications it is good for, and how to use it. Anything else usually is wasteful and unnecessary and can be looked up in more formal works.

In spite of brilliant exceptions, the applied mathematician is less often in position to do his own mathematical research. The conditions under which he works ordinarily are not favorable for leisurely reading, contemplation or this kind of research. He is hampered by noise, pressure, lack of privacy, rustiness, inadequate library (this often confuses rather than helps), preoccupation with physical details, and other work. Accordingly, his needs are best served if the material is set up so that the salient features can be overseen quickly, precisely, and completely, with as few words as possible. The emphasis, therefore, should be more on manipulation, procedure, and methods of solution than on derivations, proofs, or philosophy involved, although these have their place if presented briefly.

In the case of differential equations, expressions from vector analysis, etc., it is important to state what each term (or even the whole expression) means physically in different fields of application. It would be a great help to have a tabulation of the different ordinary and partial derivatives, with that they mean in different sciences. Likewise, it would be useful to tabulate the more important differential equations (ordinary and partial) used in science and engineering, with interpretations and an outline of the methods of solution available, together with some examples of the solutions obtained. Sometimes it is instructive to indicate the mathematical solutions that result when boundary conditions are ignored.

Most students have difficulty with the meaning and application of certain concepts. It would help such people greatly to give numerical and other examples from mathematics, science, physics and engineering, or their subdivisions, as mechanics, hydraulics, fluid flow, heat, elasticity, sound, electricity and magnetism, etc.

To obtain a result when exact solutions are unwieldy or cannot be obtained, a section should be devoted to the best approximation methods available for obtaining solutions graphically or numerically. This would include algebraic and transcendental equations, derivatives, definite and indefinite integrals, ordinary and partial differential equations, calculus of variations (as the Rayleigh or Ritz Method), integral equations, matrices, etc.

In these days, it would be helpful to list also some of the special slide rules, machine methods, and large-scale computors, with some indication of their capabilities and limitations for computation and industrial applications.

Summary

To prepare a work of the kind envisaged here will not be easy. The mark to shoot at is not too definite. The need is different for differt people and changes with time. To get it out at a popular price will be something of a problem. But a suitable 1, 2 or 3 volume work would save many times its cost. Anyway, it is clear that some important bets have been overlooked and that such works can be made more useful for instruction, review, or reference if the problem is studied by a competent group and the work tailored to fit more nearly the job to be done. Such works are not for the novice, but still they must be addressed to those who are something less than accomplished mathematicians. The possibilities of using more common everyday

language have scarcely been explored. Of course, it is not always possible or desirable to get away completely from the conventional mathematical terms, language or treatment. It would be desirable to give some examples to show how certain topics were presented and how they should be presented. But this is impractical in a paper of this length. An example of the treatment proposed here might be the section on Mathematics, pages 2–02 to 2–48 of Eshbach's "Handbook of Engineering Fundamentals." See particularly pages 2–13 to 2–23. It is imperative to make such texts less a puzzle, more standardized, and a better vehicle for transmitting the information. It is hoped that future writers and publishers will recognize the problem and make a group attack upon it.

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

TIMELY TIPS

The Value of Exaust Gas Analysis

By JAMES L. EDWARDS

Associate Professor, Mechanical Engineering, Clemson Agricultural College

In conducting experiments on exhaust gas analysis, the writer has noticed that many students concentrate so on mastering the physical manipulation of the Orsat that they either fail to grasp, or minimize, the real significance of gas analysis. Clouded in their thinking, or even pushed out of the picture, is an appreciation of the fact that exhaust gases can, and do, tell a story of the type combustion from which they resulted. Sometimes completely overlooked is the knowledge of why the CO_2 content alone in an exhaust gas resulting from the combustion of fuel and oxygen is indicative of the conditions surrounding this chemical reaction. To emphasize the need and the value of knowing the composition of an exhaust gas, the writer has found the following approach helpful.

First, point out to the students that a deficient supply of air results in an insufficient number of oxygen molecules for the complete liberation of the chemical energy stored within the molecules of carbon, hydrogen, and possibly sulfur, in the fuel. An incomplete liberation of energy means an economic loss and thus is wasteful in terms of dollars and cents because something has been paid for which is not being fully utilized. Second, call attention to the fact that an excess supply of air results in a greater than necessary quantity of oxygen molecules. This surplus of oxygen causes the complete liberation of the chemical energy in the fuel (assuming proper mixing) but represents an excessive heat loss out of the stack as the excess air has to be heated through the same temperature range as do the normal products of the combustion. Also, this extra supply of air furnished represents a larger volume to be handled by the fans and ductwork which in turn entails larger installed capacity and greater expense. Obviously then, combustion with the theoretical amount of air is desired (provided mixing is complete) as it represents both the complete liberation of chemical energy and a low stack gas loss.

With this fact firmly established the writer then has each student write the equations for the combustion of a single hydrocarbon such as propane, C_3H_8, for example with theoretical air and with 80% and 120% theoretical air. The following equations result:

(a) Stoichiometric : $C_3H_8 + 5\,O_2 + 18.9\,N_2 \rightarrow 3\,CO_2 + 4\,H_2O + 18.9\,N_2$

(b) 80% : $C_3H_8 + 4\,O_2 + 15.12\,N_2 \rightarrow CO_2 + 2\,CO_2 + 4\,H_2O + 15.12\,N_2$

(c) 120% : $C_3H_8 + 6\,O_2 + 22.7\,N_2 \rightarrow 3\,CO_2 + O_2 + 4\,H_2O + 22.7\,N_2$

A study of the exhaust products reveals that for theoretical combustion there results 3 mols of CO_2. Since there are 25.9 mols of products formed, there is then a percentage by volume of CO_2 in the products equal to 3/25.9 or 11.6%. Similar analysis for the remaining two equations shows that for combustion with 80% theoretical air, the per cent CO_2 in the

exhaust products is 4.52% whereas with 120% theoretical air it is 9.78%. These figures establish the fact that the highest per cent CO_2 is obtained when the correct quantity of air is supplied for the fuel.

This approach to the problem usually convinces a student of the value of exhaust gas analysis in general, and of the importance of determining the per cent CO_2 in the products in particular.

Reprints Available . . .

Reprints of the "Code of Ethics of Interviewing Procedures can be obtained from the Secretary's Office for 15¢ each or $8.00 per hundred.

Also available are copies of the "Manual of Graduate Study." The price is 50¢ per copy.

The "Report of the Committee on the Improvement of Teaching" is available for 15¢ each or $8.00 per hundred.

All orders should be accompanied by a check or money order.

Minutes of Executive Board, New York City, N. Y., January 18, 1954

A meeting of the Executive Board of the American Society for Engineering Education was held on Monday, January 18, 1954, at the Statler Hotel, New York City, New York. Those present were: L. E. Grinter, *President;* W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents;* G. W. Farnham, *Treasurer;* A. B. Bronwell, *Secretary.*

Report of Secretary

The Secretary reported as follows:

1. The UPADI Convention for 1954 will be held in Sao Paulo, Brazil, August 2–13, 1954. The ASEE has been asked to appoint one representative. Action was deferred pending more information as to who would attend the Conference.

2. The EJC has achieved substantial agreement with the National Science Foundation on the method of handling the National Scientific Register of Engineers. Instead of attempting to keep an up-to-date list of all outstanding engineers, it has been decided that there shall be a finder list, consisting of approximately 5,000 names of people engineers. This finder list can then be used to locate needed personnel in any specialized branch of engineering on short order if an emergency should arise.

3. Who's Who in Engineering will be available in February, 1954.

4. At the Engineering Manpower Commission it was brought out that UMT is shelved for this Session of Congress at the request of the President, pending reorganization of the Reserves. The Reserve reorganization plan calls for setting up an immediately available reserve corps with a high degree of training which could be called on short notice in the event of a national emergency. This will be backed up with secondary reserves which would be selectively called in such a manner as not to cripple industry.

5. It has been pointed out that draftees in the Armed Forces can be recalled back to civilian service three months ahead of their normal termination date if they have a contract for services. This feature might be helpful to engineering colleges which are hiring personnel for either research or faculty positions.

Report of Treasurer

1. The financial report for the second quarter was presented and accepted. It was estimated that the income and expenses projected ahead to the end of the year would come close to the budgeted figures, except for Institutional Dues which are approximately $1300 over the budgeted amount.

2. The Board voted to transfer the Life Membership fund to the general fund of the Society and to discontinue the practice of transferring $25 annually from the general fund of the Society to Life Membership.

3. The Secretary stated that the work of the Headquarters office staff is becoming very heavy and will continue to grow with the planning of the Annual Meeting superimposed upon the normal business. The Executive Board voted an additional $500 for office secretarial help.

4. The Secretary reported that he had been asked to take on the Chairmanship of the EJC Committee on Secretaries. This Committee shapes up a number of the programs of Engineers Joint Council and therefore is a rather influencial Committee. Since this is a non-recurrent item, the Executive Board voted to authorize $500 additional travel to be charged to the Special Projects Reserve.

5. The Executive Board voted to charge the $250 travel expense of the Sub-Committee on Physics against a special projects reserve.

Request of Trade Associations for Article

A request of the American Trade Association Executives for an article dealing with

how Trade Associations can assist engineering education was referred to the ECRC.

Educational Television

The program of the American Council on Education for the expansion of educational television was reviewed. It was suggested that the ASEE appoint a representative to the American Council's Committee. Vice President W. C. White will write to Dean Sweigert, Chairman of the Educational Methods Division for his recommendations.

International Relations (ECAC)

Vice President Everitt stated that the Committee on International Relations is studying the possibility of getting industrial acceptance of the principle of hiring foreign students so that these students can gain experience in American Industry. If the National Association of Manufacturers could be persuaded to recommend this to its constituents, this might help to break down the barriers of industry opposition to the hiring of foreign students. The Secretary reviewed previous correspondence relating to a proposal by Dr. Newby of the Imperial College of London and Professor Arthur Tichenor of Purdue University to bring students from England to the United States for industrial experience.

Annual Meeting

The program for the General Sessions and principal events at the Annual Meeting was outlined as follows:

On Monday afternoon there will be a Session entitled Reports of ASEE Committees. This will include reports of the Humanistic-Social Division, Committee on Ethics, Engineering Manpower Committee, Salary Survey of ECAC (if completed by that time) and the Summer Institute Program. The General Session on Tuesday morning will be scheduled for 9:00 A.M. and will include the election of officers and addresses by President Morey (University of Illinois) and President Grinter. There will then be a 1½ hour panel discussion of the final report of the Committee on Evaluation of Engineering Education The ECRC General Session on Wednesday morning will have 3 or 4 speakers who have made distinctive creative contributions, discussing the problems of creative thought. The Thursday morning General Session will be a joint Session of the ECAC, Educational Methods Division, Committee on Recognition and Incentives for Good Teaching, and YET dealing with the subject of recognition and incentives for good teaching.

General Council members and wives will be guests of President Morey at a dinner meeting on Monday evening. The Council will also hold a breakfast meeting on Friday morning.

The ECRC and ECAC will have a joint dinner meeting on Tuesday evening to commemorate the founding of the first Engineering Experiment Stations at the University of Illinois and Iowa State College.

There will be a President's tea and reception at 8:30 P.M. Tuesday. The General Entertainment will consist of a play on Wednesday evening. The Annual Banquet will be on Thursday evening. President Keith Glennan of Case Institute has consented to speak.

There will be a breakfast meeting of the Chairmen of Sections and Branches Wednesday morning and a breakfast meeting of Chairmen of Divisions and Committees on Thursday morning. It was suggested that these be cafeteria breakfasts in order to speed up service.

The Executive Board voted to accept the budget proposed by the University of Illinois and allow a registration fee of $4.00 per member.

Humanistic-Social Project

The grant of $30,000 to ASEE by the Carnegie Corporation was announced. The Executive Board recommended that an agreement with North Carolina State College be negotiated for Professor Gullette's services from January 1, 1954, to September 1, 1954. It was suggested that the project might best be handled by a Steering Committee of five to seven people and an Advisory Board which would meet less frequently, consisting of fifteen to twenty outstanding authorities. Vice President White will arrange for a meeting with Dr. Gullette and Dr. Olmsted.

Evaluation of Engineering Education

President Grinter stated that the General Electric Company had offered to contribute $10,000 to the Society for the Evaluation of Engineering Education project. The

next meeting of the Evaluation Committee will be in Atlanta, Georgia on February 18–20. Sub-Committees will be appointed at that time to prepare a draft of the final report.

By-Law Amendment

The Amendment to By-Law IV relating to dues of individual members was unanimously approved by the Executive Board. The Amendment will be submitted to the General Council for vote about February 1 and to the Society membership for vote in April. A Teller's Committee consisting of Dean Owens, Dean Treise, and Professor Obert was recommended.

Printing Costs

Mr. Farnham presented estimates on costs of printing the *Journal of Engineering Education* using the off-set process. These showed no savings on printing of the monthly issues, but a possible saving of approximately $1900 on the *Yearbook* after the first year. Mr. Farnham will clear up several matters relating to these estimates.

Summer Institute Program

The Secretary reported that the National Science Foundation had approved the proposals for the two Summer Institute programs. (Information regarding these conferences is given elsewhere in this issue of the JOURNAL.)

The Executive Board discussed future programs for the Summer Institute Conference. Suggestions included conferences on combustion, fluid mechanics, thermodynamics, and graduate study.

Cooperative Research Foundation

A request by the Cooperative Research Foundation for funds to prepare a directory of Engineers and Scientists for use of foreign visitors was rejected.

Social Security for Secretarial Staff

The Secretary pointed out that the Society does no provide Hospitalization nor Social Security for the secretarial staff. This affects only one of the office secretaries, since the other two have such benefits in connection with their husbands' employment. The Executive Board suggested that the Secretary inquire about possible ways of getting Social Security benefits for the other Secretary.

Application for Institutional Membership

The Executive Board voted to grant active institutional membership to the University of Dayton and Associate Institutional membership to International Resistance Company and the America Machine and Foundry Company.

Exchange of Publications with UPADI

A request of EJC that the Engineering Societies consider exchange of technical publications with Latin American Countries was discussed. It was recommended that the Society review its present list of free distribution of the JOURNAL and revise this to include institutions which will make the JOURNAL available to the largest number of people in foreign countries.

Next Executive Board Meeting

The Executive Board voted to hold its next meeting at Rolla, Missouri on April 9. Transportation will leave St. Louis at 8:00 A.M. in order that the meeting start at 9:30 A.M. This meeting will be held in conjunction with the meeting of the Missouri-Arkansas Section.

Respectfully submitted,

ARTHUR BRONWELL,
Secretary

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

PROFESSOR OF PHYSICAL METALLURGY—experienced in research direction and graduate instruction. Ph.D. or equivalent, to head educational option in physical metallurgy and direct thesis and contract research. Excellent opportunity for expansion in an outstanding center in the Middle Atlantic region. MR–1.

INSTRUCTOR IN ELECTRICAL ENGINEERING for September, 1954, to teach undergraduate theory and laboratory. Opportunity from graduate work in electronics or control. Apply to Chairman, Division of Engineering, University of Rochester, Rochester 3, New York.

INSTRUCTOR IN CHEMISTRY (ENGINEERING Field) to take charge and build up department in an Eastern Technical School; preferably a man with advanced degree and some industrial experience, who desires to teach and has leadership ability. Opportunity for research. MR–2.

INSTRUCTOR IN ELECTRICAL ENGINEERING. Man who is familiar with electric power engineering and also who has some knowledge of electronics, preferably one with some industrial experience. For the right man, permanent position and advancement. MR–3.

(1) ENGINEERING DRAWING Teacher-Drawing, descrip. geom., machine design. (2) Production Processes Teacher-Machining, welding, casting, metallurgy. (3) Construction Engineering Teacher-Surveying, str. of metls., constr. pract. M.S. degree plus industrial experience. Excellent opportunities in young dept. for instructor or assistant professor. New bldg. and equipt. Good salary scale. San Jose State College, San Jose, Calif.

PENNSYLVANIA STATE UNIVERSITY. Instructors for off-campus centers in electrical, structural, drafting and design subjects. Faculty participates in hospitalization, retirement, insurance, and tenure plans. Apply to Terminal Study Dept., General Extension Bldg., State College, Pa.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
*Upper New York	Cornell University	October, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ARCHER, DAVID H., Assistant Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Penna. C. C. Monrad, Lawrence N. Canjar.

BAKER, DAVID FLOYD, Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. Paul Lehoczky, Gordon B. Carson.

BOUTILIER, OSCAR DAVID, Instructor in Civil Engineering, University of Maine, Orono, Maine. W. S. Evans, G. K. Wadlin.

CANNON, MICHAEL R., Professor of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

CARNAHAN, F. L., Associate Professor of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

CAVALCONTE, CHARLES C., Instructor in Electrical Engineering, Manhattan College, N. Y. C. Brother A. Denis, R. T. Weils, Jr.

CRYDER, DONALD S., Head of Department of Chemical Engineering, Pennsylvania State University, State College, Penna. J. H. Moore, R. E. Armington.

DALY, JOHN FRANCIS, Instructor in Mathematics, St. Louis University, St. Louis, Missouri. V. J. Blum, J. B. Macelwane.

DAVIS, DONALD W., Associate Professor of Electrical Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, L. H. Archer.

DIETZLER, JOHN PATRICK, Executive Assistant to the Deans, St. Louis, Mo. J. B. Macelwane, V. J. Blum.

DOWLING, ROY E., Instructor in Mechanical Engineering, Lafayette College, Easton, Penna. J. H. Fernandes, H. C. Hamilton.

FERIDUN, KEMAL KLEMAN, Instructor in Mechanical Engineering, Lafayette College, Easton, Penna. A. W. Luce, H. C. Hamilton.

FREEMAN, JACK, Instructor in Industrial Engineering, New York University, N. Y. David B. Porter, John W. Snell.

GENTILE, RALPH G., Assistant Professor of Electrical Engineering, Rice Institute, Houston, Texas. Frank Zozzora, Mike V. McEnany.

GRIFFITH, JOHN EDWARD, Instructor in Engineering Mechanics, Pennsylvania State University, State College, Penna. W. R. Shaffer, J. W. Breneman.

HAM, JAMES MILTON, Associate Professor of Electrical Engineering, University of Toronto, Toronto, Ontario. L. S. Lauchland, G. F. Tracy.

JACKLIN, H. M., Professor and Head of Mechanical Engineering, Ohio Northern University, Ada, Ohio. J. L. Klingenberger, L. H. Archer.

JASTRZEBSKI, ZBIGNIEW DAMAZY, Associate Professor of Chemical Engineering, Lafayette College, Easton, Penna. E. L. McMillen, Hance C. Hamilton.

JENNINGS, NORMAN F., Instructor in Mechanical Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, Lawrence H. Archer.

LINDLEY, KENNETH EUGENE, Assistant Professor of Electrical Engineering, South Dakota State Cellege, Brookings, South Dakota. W. H. Gamble, J. O. Storry.

LUCAL, HAROLD M., Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn. H. A. Sawyer, Jr., R. J. Kochenburger.

MACCONOCHIE, IAN OLIPHANT, Instructor in Mechanical Engineering, Duke University, Durham, N. C. R. E. Lewis, H. N. Haines.

MORROW, DAVID CLARENCE, Professor of Mathematics, Wayne University, Detroit, Mich. R. H. Schoonover, S. F. Hicks.

PALMER, ROBERT S., Assistant Professor of Agricultural Engineering, University of New Hampshire, Durham, N. H. E. R. Stapley, B. P. Rines.

SCHALLER, GILBERT S., Professor of Mechanical Engineering, University of Washington, Seattle, Wash. B. T. McMinn, E. E. Day.

SCHERBA, MICHAEL B., Assistant Professor of Electrical Engineering, Wayne University, Detroit, Michigan. H. M. Hess, R. W. Grant.

SCHWEBKE, HOWARD JOHN, Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. B. Doke.

SEBAN, RALPH A., Associate Professor of Mechanical Engineering, University of Calfornia, Berkeley, Calif. Harold Johnson, G. S. Emmerson.

SHULDINER, PAUL WILLIAM, Instructor in Civil Engineering, Ohio Northern University, Ada, Ohio. J. F. Klingenberger, L. H. Archer.

SIMPSON, HOWARD, Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass. M. J. Holley, Jr., O. G. H. Dietz.

SMITH, RAYMOND VIRGIL, Assistant Professor of Mechanical Engineering, New Mexico College, State College, N. M. J. P. Morgan, A. M. Lukens.

STELSON, THOMAS EUGENE, Assistant Professor of Civil Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. F. T. Mavis, E. D'Appolonia.

TOOR, HERBERT L., Assistant Professor of Chemical Engineering, Carnegie Institute of Technology, Pittsburgh, Penna. Carl C. Monrad, Lawrence N. Canjar.

VELLINES, WESLEY ELMORE, JR., Chief Engineer, The C. & P. Telephone Company of Viriginia, Richmond, Va. R. A. Marr, Jr., John S. Jamison.

VOGEL, MILTON LEON, Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wis. R. R. Worsencroft, H. B. Doke.

VOGT, CARL J., Professor of Mechanical Engineering, University of California, Berkeley, Calif. G. S. Emmerson, H. N. Johnson.

WILTSE, JAMES CORNELIUS, JR., Instructor In Electrical Engineering, Johns Hopkins University, Baltimore, Maryland. Morris S. Ojalvo, John L. Artley.

ZUK, WILLIAM, Instructor in Structural Engineering, Cornell University, Ithaca, New York. John G. M. McEntyre, Arthur J. McNair.

307 new members elected this year

Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at the Pennsylvania State University, State College, Pa., and enclose a check or money order in the amount of $2.50.

In The News

Interlingua

Scientists and engineers are giving the Western world something else to talk about—or with—a new language called Interlingua. In 1923, an international group of technical men, anxious to simplify the exchange of ideas and developments in science, organized to overcome the language barrier. The result was Interlingua, a union of five European tongues, with the peculiarities of each left out. The languages are English, French, Italian, Spanish, and Portuguese. A little German also is included. Twenty-five years of research by linguistics experts culminated in a book on Interlingua grammar, which is simplified in comparison to the European languages, and a 27,000-word Interlingua-English dictionary, which includes 17,000 technical terms. Currently being printed is a book using pictures to teach vocabulary entitled, "Interlingua a Prima Vista" (Interlingua at First Glance). An English-Interlingua vocabulary is about half finished.

The first publications in the new language were begun in 1952. "Spectroscopia Molecular" is one of them. It is published monthly by Dr. Forrest F. Cleveland, professor of physics at Illinois Institute of Technology, Chicago.

"Most scientists," he said, "may be surprised to find that they can read Interlingua with little reference to the dictionary or grammar." An example: "Energia es necessari pro toto que occurre in le mundo. In tempores passate le plus grande parte del energia applicate esseva fornite per le fortia muscular del homines e del animales domestic." The English equivalent is: "Energy is necesary for all that occurs in the world. In past times the greatest part of the applied energy was furnished by the muscular strength of men and domestic animals."

Although at present it is primarily a language to be read, it can be spoken, too. But the importance of Interlingua now is its usefulness in the fields of science and engineering.

Chief of the Interlingua division of Science Service is Dr. Alexander Gode, who holds a doctor's degree in Germanics from Columbia University and has taught modern languages at both Columbia and the University of Chicago. Dr. Gode was director of research for the International Auxiliary Language association. It was formed in 1923 by committees of the International Research council, by the American, British, French, and Italian associations for the advancement of science, the American Council of Learned Societies and other specialist groups. Dr. Gode presented the theory behind Interlingua in an article entitled, "The Case for Interlingua," in Scientific Monthly magazine, August, 1953.

It was summarized in four points:

1. The languages of the world cannot be reduced to one universal pattern. Instead, every language falls into one of many possible molds.

2. The internationalism of the twentieth century is propelled by ideological forces which have originated in the western world. These forces are understandable only in the molds of occidental speech and thought.

3. The languages of the west are so closely related to each other that it is sound to think of them as variations of one type language which is called Standard Average European.

4. To become international a language must have a force behind it to make it

spread: for example, Latin's influence spread through Europe with the Roman colonizing legions, Christianity, and the revival of classical Latin during the Renaissance. The motivating force of language in the twentieth century is science.

The concepts of science, Dr. Gode wrote, emerged in Europe, and the natural supranational language of science is Standard Average European. Interlingua, he concluded, is to date the most satisfactory system of language formed from Standard Average European.

Reserve this date . . . .

June 14-18, 1954

ANNUAL MEETING

UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

College Notes

A joint five-year liberal arts-engineering curriculum for students at the University Heights center of **New York University** has been announced. The program will be available beginning with the fall 1954 semester. It enables students to obtain the degrees of bachelor of arts and bachelor of engineering in a particular branch of engineering. Students declare their intention of pursuing the combined curriculum after the freshman year. The first-year curriculum is a normal liberal arts program. Each successive year introduces a greater proportion of engineering courses until the fifth year when the program consists of engineering courses entirely. Degrees are awarded only after the fifth year, at which time the student has completed a major in engineering and two minors in liberal arts areas.

* * *

The **California Institute of Technology** is inaugurating a "3-2 plan" for the admission of men from certain selected liberal arts colleges as juniors at Caltech. Colleges with which arrangements for participation in the plan have been completed include Occidental College, Los Angeles; Pomona College, Claremont; and Whitman College, Walla Walla, Wash. Under the plan, a student may enroll in a cooperating college for an agreed-upon program for three years. On recommendation of the college he will then be admitted to Caltech as a junior. When he satisfactorily completes two more years of work at Caltech—for a total of five years of study—he will receive simultaneously the bachelor of arts degree from the college and the bachelor of science degree from Caltech.

Do You Know—

▶ To the ladies . . . a French Provincial estate, complete with formal gardens, and a reflecting lake, set down in the middle of Illinois cornfields! Hard to believe, isn't it! . . . but the hostesses at the University of Illinois are hoping to take the visiting ASEE wives to Allerton for luncheon and a visit at annual convention time in June. And a family square dance party Monday night, bridge and luncheon at the Country Club, tips and facts on fine china, pottery and other dinnerware by a ceramics expert, and a special demonstration of all the wonderful desserts you can make from ice cream will be among the other events being arranged. So come along with your husband, see your old friends, get acquainted with us, and have fun!

The children's program will be a humdinger! The Illinois' children are all excited about hostessing under the Buddy System. Honest to goodness Engineering Mothers are running the show sparked by Mrs. Edward Jordan, with a rootin'-tootin' time for teens at their own clubroom with Mrs. Norman Parker keynoter.

Crafts, games, swimming, picnic lunches, science explorations, and just plain entertainment pack the day 9:30 to 5, Tuesday, Wednesday, and Thursday. The kids won't want to miss it, and Mom will be a free woman. The age groups will be 4–5; 6–7; 8–9; 10, 11, 12; and teenagers.

Register the children as far ahead as possible so they can be accommodated.

▶ This year the ECRC and ECAC are jointly commemorating the Fiftieth Anniversary of the founding of Engineering Experiment Stations in the U. S. by a dinner open to the Society membership. The speaker will be Dr. Lee DuBridge, President of the California Institute of Technology. The first Engineering Experiment Stations in this country were set up at the University of Illinois and Iowa State College.

▶ The Technical Institute Division has prepared and published a bulletin "Literature Significant to Education of the Technical Institute Type." Copies of this 60-page annotated bibliography are available at $1.00 each from Mr. Karl O. Werwath, 1025 N. Milwaukee Street, Milwaukee 1, Wisconsin.

▶ The Committee on Evaluation of Engineering Education held a two-day meeting at Atlanta, Georgia, February 19–20 to review some of the more controversial issues in the Preliminary Report and also to appraise the material presented in some 118 reports from Institutional Committees which have been working with the ASEE Committee. The Institutional Committee reports provided extremely helpful suggestions, many of which will be incorporated in the final draft. You will be interested to know that the Committee decided to delete the two issues which have been most controversial—bifurcation and the plan of starred accreditation for exceptionally meritorious curricula. There was almost universal disapproval of these two proposals.

The Committee recommended that the report presented in June 1954 be an interim report which would be reviewed during the next two years for subsequent modification, as well as to evaluate the progress in implementation of the report.

▶ The conference on Solid State Physics held at the University of Illinois, March 8–10, sponsored jointly by ASEE and the National Science Foundation, helped to clarify the essential fundamentals in modern physics as they relate to undergraduate engineering education. The

Committee came forth with recommendations of subject matter which might be included in one or two undergraduate courses and the manner in which this material can be utilized to provide a more scientific base underlying the engineering courses. It was the belief of those present that the inclusion of such material at about the Junior year could greatly strengthen the scientific foundations of the courses in engineering materials, electronics, metallurgy, strength of materials and others.

Watch for a summary of this Conference in the May issue of this Journal. Also, may we remind you of the Open Conference on this subject to be held at Carnegie Institute of Technology, June 21–25, 1954. For information write to Assistant Dean John Graham, Carnegie Institute. Dr. Frederick Seitz at the University of Illinois organized the closed conference and served as its efficient Chairman.

► There will be a similar conference, sponsored jointly by ASEE and the National Science Foundation, dealing with Nuclear Physics in Engineering Education. The Closed Conference will be held at Columbia University, April 21–23, and the Open Conference at Northwestern University, September 7–11. For information relating to the Open Conference, write to Professor Robert Young, Technological Institute, Northwestern University.

► The Mechanics Division is building its Summer School, June 11–12 at Urbana, around the theme of Graduate Study in Mechanics. The detailed program is too long to print, but the subjects sound both vital and interesting, ranging from mathematical preparation, mechanics of solids and fluids, advanced dynamics, solid state and nuclear physics, thermodynamic effects on stress analysis and vibrations, all the way to discussions of future programs. If you wish information, write to Professor Herbert R. Lissner, Wayne University, for details.

► Mechanical Engineering will hold its Summer School at Navy Pier, University of Illinois in Chicago, June 18–25. The program, aimed primarily to help the young instructor, deals with the "Teaching of Machine Design and Manufacturing Processes" and covers the entire gamut from A to Z. Professor K. E. Lofgren of Cooper Union is in charge. Here's a chance to dangle a fishing line out the classroom window and strike up a jackpot for the largest catch.

► The Committee on Engineering Economics is busy planning a two-day Summer School to be held at Urbana on June 12–13 preceding the Annual Meeting. There will be a series of seminars under the general theme "An Evaluation of Analytical Techniques of Engineering Economy," which will include "Enterprise Economics," "National Economics," "Accounting," "Statistical Techniques," and "Operations Research" as they bear on Engineering Economics. Professor A. J. Lesser of Stevens Institute, who is Chairman of the Division, can supply further information.

► From our Electrical Engineering Division comes information relating to their Summer School on "Design of Digital Control Circuits" on June 18–20 at Urbana. This will feature several distinguished Digital Computerists from the Bell Telephone Laboratories, together with demonstrations. For information, write to Dean L. V. Bewley, Lehigh University.

► The Humanistic-Social Division will hold a Summer School after the Annual Meeting, June 18–20, 1954, at Urbana. This will be a workshop to launch the new Humanistic-Social Research Project. Professor Sterling Olmsted, Rensselaer Polytechnic, will send you further information if you write.

(*Continued on page 482*)

Engineering Laboratory Courses

By JAMES N. THURSTON

Associate Professor of Electrical Engineering, California Institute of Technology

Laboratory courses are almost universally considered to be an important part of an engineering curriculum, but there is no general agreement as to what constitutes a good laboratory program. However, there do appear to be certain principles upon which laboratory instruction should be based. It is the purpose of this discussion to present one viewpoint on the subject by first stating some of these principles, and then discussing or defending them. Particular reference is made to electrical engineering in order that specific details may be considered at times.

I. The university as a whole, the engineering college or division, and the department in question should have a basic guiding philosophy of education, and this should be subscribed to, in general, by the staff, including laboratory instructors. Some engineering colleges believe in a highly specialized training, some favor a broad general coverage, while still others prefer a more thorough emphasis upon scientific principles. Of course any good school has room for a wide variation in methods and emphasis in its courses, but difficulties are sure to arise if an instructor is completely out of sympathy with the basic aims of his institution. For example, a laboratory instructor who is convinced that his students should become skilled technicians, such as might graduate from a trade school, should not attempt to force his opinion on his colleagues and his students when it is clear that the school believes in an entirely different approach. Educational philosophies change, of course, and every staff member should be free to speak and work for his ideas, but he should not be a deliberate obstructionist.

II. As a corollary to item I, it follows that laboratory courses should be planned to fit in with the general aims of a department. Furthermore, there should be a single laboratory *program*, rather than a large number of distantly related courses. As aims change, and as technological developments occur, laboratory instruction must, as a rule, change accordingly. Carefully planned changes in laboratory programs are far preferable to indiscriminate and drastic revisions. Too often there is little or no continuity in laboratory supervision, with the result that work done in the past is frequently wasted or overlooked in the confusion of a course revision. Graduate students, who are often given complete responsibility for laboratory courses, simply do not stay in the department or do not remain in charge of the courses for a long enough time to provide the necessary stability. Throughout the country there must be thousands of reams of old laboratory notes and experiment sheets that have been stored away and forgotten, only to be "superseded" by material which, upon inspection, would be found to duplicate almost exactly the earlier work.

III. Convenience of scheduling, ease of grading, and economy of operation should never be given *primary* consideration in the planning of a laboratory course.

IV. In order to be useful, a laboratory program *must* entail some preparation by the student beforehand, and *must* allow for some study and contemplation of the results obtained. Time for this outside

preparation should be clearly allocated, preferably in the catalog, and not "stolen" from other subjects.

V. Laboratory instruction should be recognized as an important part of a college program. Adequate credit should be given to those who handle laboratory courses, and senior staff members should be encouraged to participate in this type of teaching. Too often laboratory assignments are given to young and inexperienced instructors, without supervision, simply because the assignments are clearly tedious, and underrated in hours of assigned credit. The result of such a policy is obvious. Laboratories are expensive to maintain and operate. They should either be given adequate attention or eliminated entirely.

VI. Methods of laboratory instruction should be graduated to meet the student's needs as he progresses. Early courses should be arranged to offer more aid and guidance than later ones. In any case, completely detailed laboratory experiment instructions should be avoided, since their successful completion tends to show only that the student can read, that the equipment is in operating condition, and that the instructor was clever to have worked up such a good experiment.

VII. Experience in report writing is essential, and all complete laboratory programs should include attention to this principle. It may not be necessary or desirable to require formal reports in each separate laboratory course, but some report-writing experience should be incorporated in the whole program. Laboratory instructors, in marking reports, should be as careful of details related to expression, grammar, and punctuation, as they are with respect to purely technical aspects of the report.

VIII. Laboratory subjects should, if possible, be listed under separate titles and numbers in the catalog. Often it is stated that better correlation between class and laboratory is obtained if the two are listed as a part of one subject. Actually this seldom is true, since the laboratory and classroom instructors are usually not the same, the facilities are such that the same groups cannot be together in both places, and scheduling problems usually results in various mixtures of class and laboratory groups. The advantages of separate listing are considerable. Each course must stand alone and justify its existence, there is much more flexibility available for those students who have irregular schedules, and there is likely to be more attention paid to a separate laboratory course than to one which is only a part of combination. Every possibility of correlation between laboratory and class that exists with the combined method of listing is possible with the separate system.

IX. Active student participation in the laboratory should be encouraged by (a) prompt and accurate grading of laboratory performance, (b) limiting laboratory teams to the smallest possible number that can do the work (often two per team in undergraduate electrical engineering), (c) measures designed to minimize report copying and other illegal use of "files."

Other principles could be stated, but the preceding ones seem to cover the most important points. Even if there were complete agreement with the above statements, there would be many problems concerned with the detailed operation of laboratory courses. Further thought and discussion are needed on the general subject of laboratory instruction, as this area of engineering education seems to have received little attention in recent years.

Notes on: "How to Improve Our Engineering Curriculum"—Can we benefit from a comparison of the American with the European teaching methods?

By R. K. BERNARD

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The author of this paper, Dr. R. K. Bernhard, Professor of Engineering Mechanics at Rutgers University, has been educated in Europe and taught engineering subjects in this country since 1938. His experiences seem to qualify him to present a comparison and analysis of the basic teaching methods as practiced on both continents.—EDITOR.

I. *Introduction*

The great progress in the physical sciences, stimulated by developments during World War II, raises the urgent and highly controversial question at many of our Engineering Colleges: "What shall we do with our engineering curriculum in order to cope with all these new developments?"

The purpose of the following notes is, *first:* to discuss a few basic concepts of our present teaching methods, *second:* to compare them with certain European procedures, and *third:* to investigate whether we can benefit from this comparison by improving our curriculum and live up to the new situation.

This discussion is limited to technological questions only. Equally important topics on studies of the humanities are beyond the scope of these notes.

II. *General Concepts*

The fundamental questions involved are: "Do we want to educate primarily the better student, do we intend to help only the average man, or do we need programs for both?"

In other words: "Is our main purpose to raise only an elite, or to restrict everyone to the same average education, or to allow each student to make the maximum use of his abilities?"

While the European methods follow, in general, the "leitmotif" to assist a selected few, our system tends to the obviously more democratic "credo" trying to raise the educational standard of the masses. Unfortunately, the American undergraduate system tends to limit the opportunities for the more gifted students.

It certainly cannot be stated that one of the many avenues of approach is better than the other; an historical development will always follow its own path in order to fulfill definite aims.

Furthermore, whatever teaching methods are used, and often in spite of a poor teacher, the brilliant student will eventually find his way regardless.

As is often the case, most systems have their pros and cons. Hence, the next questions arise: "Can we afford to continue with our present method?" and "Is it possible to modify and adapt adequately some of the advantages of the

European procedures to minimize some of the disadvantages inherent to our system?"

American System:

Our system is based on the fact that the high schools, in general, do not prepare their students as we would prefer, in particular, as far as natural sciences are concerned. Much of the desirable course material must be presented to our engineering freshmen and sophomores which could be digested during the senior high school year.

Furthermore, we consider it essential that periodic quizzes be followed by final examinations within each semester—sometimes inadvertently degenerating into "spoon feeding."

Finally, a rigid course schedule with a predetermined number of credit hours allows only a rather small deviation from this standardized procedure. Hence, not much time is left for self studies and creative thinking.

The *advantages* of this system are:

An average student will benefit mostly from progressive quizzes and finals.

The continuous process in grading our students forms a highly satisfactory, automatic feed-back system for weak pupils, for the teachers and, if necessary, even for the parents.

All three can take preventive measures at the earliest possible moment in order to remedy any further deterioration.

In addition, the poor student can be effectively eliminated at any appropriate time by our probation methods.

The mortality of senior students is relatively low, thus presenting one of the outstanding advantages of our methods.

The *disadvantages* are:

The average student, and unfortunately the mediocre one also, will be capable to squeeze his way through struggling from one quiz to the next. If necessary, he can repeat this procedure for several semesters. Too often the tendency of an instructor may prevail to let the poor candidate pass after renewed attempts.

This rigid reining, which is so necessary for the mediocre pupil, sometimes acts as horse blinders for the better student. It might prevent him from taking a broader view, that is, exploring both sides of the beaten path.

Gifted men are rather restrained since the progress in most courses must be geared down to the average. Thus the brilliant fellow has few possibilities to proceed faster or to add more courses to his allowable credit hours.

European System:

Some European systems are based on the fact that the last two high school years are subdivided into separate branches. These branches emphasize either science courses or studies of modern or of ancient languages. In case of predominance in science studies a high school student would receive adequate training in Differential and Integral Calculus. Similar possibilities exist for physics and chemistry courses.

The extensive use of comprehensive examinations is a well established practice at many European Universities. No quizzes or intermediate finals are offered. For example, the German engineering curriculum (pre 2nd World War) comprises two comprehensive examinations only—one after the sophomore and one after the senior year. Repetitions of these two tests are severely restricted.

One typical example of a problem in such a comprehensive examination for a candidate in civil engineering, majoring in bridges might be outlined. Its solution requires several days' work and may include the following items: Theoretical and practical design of a bridge in all its details; discussion why the selected type of structure is economically justified; erection procedures and excavating methods; work-time schedules; cost estimates; financing procedure and amortization. Thus the crossing of departmental border lines between Civil-, Mechanical-, Electrical-, Architectural- and Administrative-Engineering becomes obvious.

The *advantages* of this system are:

An extended preparation in physical sciences and languages during the last two high school years relieves the standard four year engineering curriculum from the above topics. It allows the introduction of other generally more advanced courses.

The better university student will benefit mostly by proceeding with these courses at his own pace. In order to survive he has to learn at an early stage, starting as engineering freshman, to stand on his own feet. He must use his own judgment to adapt the progress according to his capacity of absorbing the subject matter as required for any comprehensive examination. That means he has to learn how to integrate many different topics over long periods of time. All of these decisions present a severe and valuable challenge to his personal integrity.

The *disadvantages* are:

A large number of high school juniors have not developed enough to indicate specific abilities.

They are not capable to select the proper branch best adapted for their future university studies.

Students with poor memory will be handicapped at the comprehensive university examinations without necessarily having a lower aptitude.

A photographic memory can act in the opposite way.

Candidates with lack of confidence seldom find the courage to enter a comprehensive examination, while men with over-confidence might fail likewise.

The almost complete freedom in study methods will lead many astray, mainly due to lack of proper guidance.

Hence, the mortality at these comprehensive tests is rather high. This presents a particularly serious disadvantage since a rejection from the selected professional career comes at a rather late date.

III. *Re-Evaluation of the Engineering Curriculum*

Numerous suggestions and experiments, independent of any European procedures, have been made at many of our universities. All of them try to prevent pitfalls inherent to both systems as analyzed above.

Two of the various suggestions adaptable to our special requirements might be discussed. They present a combination of an extended four year engineering curriculum and of an honor program. Some of these plans have been advanced and are at present under serious considerations by appropriate committees at the College of Engineering of Rutgers University.

Extended Four Year Program:

The main purpose of an extended four year curriculum is to raise the standards of the present engineering curriculum and to increase the amount of studies in fundamental sciences in order to keep up with the new technological developments.

The extended four year program is based on the assumption that the last high school year may be taught at a university. In most cases the senior high school year cannot be satisfactorily modified to fit the special requirements of a revised engineering curriculum, at least not at the present time.

Furthermore, the plan presupposes that only those high school seniors who show a definite aptitude for science studies will be eligible for this program.

Hence this suggestion has a certain resemblance to some of the above mentioned European methods. It relieves the standard four year engineering curriculum from certain basic science courses.

Finally, such a plan does not extend the duration of the present four year university studies and would facilitate a raising of our standards.

It must be kept in mind, however, that many high school seniors have not matured enough to develop special aptitudes. Consequently, this choice of a science study at such an early stage must be optional and revocable.

Honor Program:

The purpose of a university honor program may be threefold; *first:* to promote

creative thinking, *second:* to urge better students, in particular juniors and seniors, to widen their scope of studies, and *third:* to enable the brilliant man to progress faster.

Only students above a specified scholastic average can become eligible candidates and must apply on their own initiative for participation in the Honor Program.

1. *Creative thinking* can be stimulated by forming a team of qualified seniors from various departments (Civil-, Mechanical-, Electrical-Engineering, etc.). This selected group will be challenged by one comprehensive problem covering a wide range of engineering fields. The solution must require not only extensive studies in the library but also a selection of the best and, if possible, new methods. Finally, a detailed analysis of the findings is essential.

Getting accustomed to team work, to develop new angles of attack, and to inspire creative and productive research, is one of the major objectives.

2. *An increase in scope* of studies might be promoted by self studies. These self studies should include regularly required as well as elective courses. For this purpose the better student will not be forced to participate in any quizzes. He has to present himself, however, for a final examination whenever he feels that he masters the subject. Generally speaking, he will have the privilege to study when and where he sees best, according to his own discretion. The time gained by not attending classes and quizzes might be used for additional courses.

Some students, particularly the "lone wolf" type, will benefit from such a liberalized procedure.

3. The above privileges might, in exceptional cases, permit a brilliant candidate to finish his studies in *a shorter time* than the prescribed four years. This reduction in time will enable him to pursue more advanced studies than are ordinarily available to the undergraduate.

Since any rigid guidance for this selected group of students is almost completely dropped, a specially appointed faculty committee ought to continuously supervise the admission, the progress, and also the dismissal from the program of any individual candidate in case of a drop in his scholastic average.

Both programs tend to make use of some of the best qualities included in some of the European systems; first, by deliberately crossing departmental border lines, and second, by eliminating most of the continuous supervision.

To avoid misunderstandings it must be emphasized that it seems equally possible to reverse this procedure and try to improve upon the European methods. This, however, is beyond the scope of the present discussion.

IV. *Conclusions*

From a comparison of American with some European teaching concepts and an analysis of the pros and cons inherent to both systems, several clues for an improvement of our present engineering curriculum may be abstracted.

Apparently the few independent somewhat heretic suggestions, as discussed previously, have the tendency to lean towards certain European methods.

In case any suggestions are accepted in one form or another, they ought to be introduced gradually and on a small scale experimental basis. It must be kept in mind that close supervision and constant changes for improvement will be necessary.

The author realizes that the plans presented so far are only a few of the many ways in which progress can be achieved. Every institution of higher learning will require or prefer different methods.

By raising these issues he exposes himself to the dangerous crossfire intrinsic to all controversial questions; if, however, further investigations along these lines have been stimulated he would feel very gratified.

The Chemical Profession in the U.S.S.R.

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The early history of the Russian Chemical Society is similar to that of the chemical societies in other countries, notably Germany. Its journal (now called "Journal of General Chemistry") started publication in 1869. The German "Berichte" started publication in 1868. The later development of the two societies differed pronouncedly. In recent years, the rapid expansion of Russian chemical education facilities, the growth of the chemical industry in Russia, the change of the social atmosphere and of the relationship with other professional and social groups has rapidly changed the objectives of the Mendeleev Chemical Society (the present name of the chemical society in the U.S.S.R.) in many respects.

In 1913, Russia had 1000 chemists. The Russian Chemical Society (known as the Chemical Division of the Russian Physico-Chemical Society, to which both chemists and phycisists belonged), numbered 415 members in 1927. The numbers of scientists in other fields were not much different. It is difficult to draw a clear comparison between the numbers of chemists in the U.S.S.R. and in the U.S.A. at the present time, interesting as this would be. The term "chemist" is not uniformly defined on the basis of education or occupation. In 1939 the number of chemists in Russia reached 50,000 and there were facilities for training about 5000 chemists and chemical engineers a year. The number of engineers of all branches trained in 1938 was 25,200. There is reason to believe that at the present time the number of chemists and chemical engineers in Russia is close to 75,000. The American Chemical Society has now about 70,000 members. It is likely that there are up to twice that number of people in the United States employed as chemists. The number of people in this country employed as engineers and biological and physical scientists was reported in 1952 to be 600,000.

The total number of graduates from Russian universities and technical colleges during the 1946–50 period was 652,000. The number of chemists among these graduates was not stated. The total number of graduates from United States universities and technical colleges during the same period was 1,630,438.* Degrees in chemistry granted during the period 1948–50 totaled 35,217 in the United States.

In 1948, 64% of all Soviet scientists including chemists were between the ages of 30 and 50. The number of women in scientific and engineering research is large. In 1941 there were over 15% women in the various technical professions in Russia and at least 25% of all students in the technical colleges were women. In all likelihood, this percentage has not decreased after the war.

Privileges Extended

Although the great majority of the professionals, including chemists and chemical engineers, did not collaborate in the revolutionary movement in 1917, many of them later stayed on their jobs and, when the industrialization drive was started in 1928, they wholeheartedly collaborated out of sheer patriotism. This attitude

* Estimated, as figures are not available for 1946–47 graduates.

was revealed even by some Tsarist generals who served the Soviet government. In the case of scientists, many privileges were extended to them and in the course of years a series of new incentives and methods of exerting pressure upon scientists was developed in order to keep them in line politically and promote their interest in research and development work along the lines laid down by the Soviet government through its industrial planning organizations and the Academy of Sciences. All these influences are relayed through the organizations in which the chemists participate. Important among these is the Mendeleev Chemical Society.

The inducements mentioned above are not much different from those available to employees in capitalist countries; they differ only in emphasis and include public recognition, award of prizes and medals, remuneration for patentable invention disclosures, election to honorary positions and promotions.

The primary objective of the Mendeleev Chemical Society is to organize the chemical personnel for the fulfillment of that part of the over-all plans of the State which is thought to be within its sphere of activity. It arranges lectures and discussions on pertinent subjects and contests for researches on problems the solution of which is urgently needed by the national economy. These problems may include a mathematical study of a given process or application of a known reaction. The pride of Russian organic chemists, the S. V. Lebedev process for the synthesis of rubber from ethyl alcohol via butadiene, resulted from one of the first contests of this type won by Lebedev in 1927. Just as societies of engineers in various branches of industry, the Chemical Society is urging its members to file invention disclosures for which the inventor may eventually be rewarded in proportion to the savings effected by his invention. A Stalin prize involves an outright award of a considerable sum of money, between 25,000 and 200,000 rubles. Election to the Academy of Sciences contributes greatly to the prestige of a scientist. On the other hand, the Mendeleev Chemical Society collaborates with such bodies as the Department of Chemistry of the Academy of Sciences in keeping the direction of the chemical researches not only close to the needs of the national economy, as described by the plans, but also close to the dogma laid down by the philosophy of the State. A meeting on the nature of the chemical bond was organized in 1951 by the Department of Chemistry of the Academy of Sciences in order to reprimand publicly the chemists who allegedly harmed Russian chemistry by insufficient recognition of M. Butlerov's views on the structure of organic molecules and supported the resonance theory of Linus Pauling. One may think that some of the chemists who recanted at that meeting and even some of the accusers paid lip service to the interpretation of the State philosophy handed down from above at that meeting but this dictate is illustrative of the type of public condemnation and criticism to which a Russian scientist may be subjected for deviation of his views from the accepted theory as well as for insufficient adaptation of his research to the needs of the Soviet industry and Soviet theoretical science as decreed by the managers of Soviet science.

Training

The training of a Russian chemist involves a four- or five-year period of study after graduation from a secondary school —i.e., after 10 years preliminary education. A chemist or chemical engineer is clearly distinguished from an assistant engineer occupying a more subordinate position. The number of these engineering assistants, who are trained according to a well developed program of technical secondary school education, is considerably larger than that of chemists and engineers. The graduate chemist may engage in teaching, research or industrial work; the latter is more frequently done by chemical engineers. In any case, he may want to pursue graduate study for an advanced degree. There are two de-

grees which he can obtain by post-graduate work, pursued either in an institution of higher learning or in an authorized research institute; this work is carried out in many cases in absentia, except for the final year or so and examinations for which the candidate appears in person. These degrees are Candidate of Science, roughly equivalent to a master's degree, and a doctor's degree, which is officially termed doctor of the respective science, such as Doctor of Chemical Sciences. The term Doctor of Philosophy is reserved for those specializing in the field of philosophy proper. In pre-revolutionary Russia, obtaining a doctor's degree involved exceedingly much work in preparation of a dissertation. At the present time, the requirements are less rigorous and some positions, such as that of full professor, are filled as a rule only by individuals holding that degree; nevertheless, there is evidence that obtaining a doctor's degree, for instance in chemistry, is still a formidable undertaking. A chemist with such a degree will almost always sign his articles with "Doctor of Chemical Sciences" following his name.

Although the rate of training chemists in the U.S.S.R. is high and in 1942 it was stated that there were 70 institutions with facilities for chemical training, considerably fewer institutions are available for graduate training and there is a constant drive, evident from the proceedings of various bodies responsible for training of scientists, to improve the graduate research and the qualifications of the upper-grade chemist. Some leaders of research are apparently so overburdened with directing research, writing, teaching, and other duties that they neglect supervision of graduate students, or "aspirants" as they are called, for which they are occasionally publicly reprimanded. A. A. Balandin, a leader in catalytic chemistry, trained within 25 years only nine people for the doctor's degree. It is to be remembered, however, that the training for the doctorate in natural sciences, agriculture and engineering was reserved until recently for institutes of the Academy of Sciences. Only in 1952 were eight prominent technical colleges and the Moscow State University authorized to award doctor degrees and accepted a total of 100 candidates for that degree. In 1947 the total number of people with doctor degrees in U.S.S.R. was reported to be over 10,000; the number of Candidates of Science, 23,000. In 1951 there were 24,000 persons in training for the degree of Candidate of Science, and their rate of training was to be doubled by 1955, as compared to 1950. Within the same 5-year period the Academy of Sciences will train 1000 persons for the doctorate and 2500 for the degree of Candidate of Science. The Academy awarded 91 doctor degrees and 361 Candidate degrees in 1952. All these numbers are not limited to the natural sciences.

Indoctrination

All higher education, including training in chemistry, involves indoctrination in Communist theory, and no individual suspected of anti-Communist tendencies will be given a responsible position.

The entire chemical research in Russia is influenced by the National Soviet Academy of Sciences and the provincial academies of sciences. In addition to the research institutes directly managed by the Academy, there is a much larger number of research institutes serving industry either on a national or a regional basis, or else serving a definite branch of an industry. The next organizational research unit in the downward direction is a laboratory attached to a plant. Important research seldom comes from these laboratories. On the other hand, the research in the national institutes of applied chemistry and in the institutes of the Academy of Sciences is carefully planned and integrated, and the progress reports underscore the number of topics on which research has been completed and those on which the completion is still pending. The chemical research institutes within the Academy of Sciences are clearly identified through their publications and progress reports; not so the in-

stitutes working for the Soviet industries. There are at least 70 chemical research institutes in the U.S.S.R. The total number of research institutes was given before World War II as exceeding 800. At least six national research institutes serve the petroleum industry.

Recognition abroad is apparently just as important to Russian chemists today as it always has been. They constitute today a vigorously growing body of relatively young, ambitious scientists who strive to assert themselves on the science stage internationally, but also as citizens of their country deserving of high esteem, which they have been given as a body, but which is constantly threatened in the case of every individual scientist.

Russian Chemistry not well followed in the United States

Language difficulties and geographical separation are responsible for a lack of information in this country about Russian chemists. Historically speaking, one of the obstacles in the way of recognition by English-speaking scientists of certain important contributions of Russian chemistry was the influence of scientists of German descent upon Russian science. Among the scientists invited at the inception of the Russian Academy of Sciences (founded in 1725) to work in that institution, the number of Germans was large; the contributions to science made by some Rusian chemists of German extraction have been great in many cases. They reported their researches in German publications, as do many other Russian scientists. Many Russian scientists with foreign names occupy important places in Russia today and are very patriotic to their country. However, credit for their researches was in the past frequently given to Germany. Thus, F. Beilstein, Paul Walden, Wilhelm Ostwald, P. P. von Weimarn and many others either started their scientific careers as Russian citizens or considered themselves Russians throughout their lives. In the St. Petersburg Technological Institute Beilstein taught for a number of years *inorganic* chemistry, while D. I. Mendeleev—*organic* chemistry. A study of the scientific literature cited by Russian organic chemists established a decrease of the German influence at the present time: around 1946 the Russian organic chemist was quoting in research papers more Russian than German references. A similar stage was reached by the American chemist in 1919. Both resulted from the rise of American chemical research.

Influence is Great

The influence of the Soviet chemical profession upon the Soviet industries is great. In line with the importance of chemistry in the Soviet industrialization plans, the third Five-Year Plan, which was to be completed in 1942 and was interrupted by the war, was termed "the Chemical Five-Year Plan" and there is much emphasis on chemistry also in the present plans. Both the incumbent president of the Soviet Academy of Sciences and the scientific secretary of the Academy are organic chemists (A. N. Nesmeyanov and A. V. Topchiev, respectively).

In the past, many new processes introduced in Russian chemical industries consisted of adaptation of foreign processes. Now original developments resulting from utilization of the available natural resources and fruition of Russian basic research occupy the Soviet chemist. It is true that a Russian chemist, just like a chemist elsewhere, has to be mindful of economics and certain chemically interesting processes are not commercialized for this reason. Speaking about such processes and claiming credit for their development, Russian chemists are very noncommittal in many cases.

Looking at the future, the Russian chemist is confident of increasing success within his own sphere of influence, but the policies of the State and their eventual influence upon him he cannot predict.

Fundamentals and Professional Thinking

By M. L. MILLETT, JR.

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According to Webster originality is "independent and creative in thought or action: inventive." If then a student can apply creative means in the solving of some fundamental problem that is new and unfamiliar to him, he has originality. Also, the student who in a given situation, can apply his thinking progressively through each step until the solution is at hand has originality or is creative in thought. What then can the engineering division and the entire college do to help the student develop these qualities?

From experience, I would like to cite examples showing why the student must be able to grasp these new and unfamiliar situations and carry them through to a successful solution. I was in a position where I had to instruct some of the graduates of our engineering colleges. One fellow in particular enters my mind. He came to us from a school in the West and from his record he was an average or perhaps slightly above average student. He was assigned to assist in some brake tests on a particular airplane. The explanation of this type of test does not occur in the normal course work pursued in college, yet it involves some of the basic fundamentals of engineering or physics. This fellow was at a loss to know what to do. Each item of procedure and data reduction had to be thoroughly explained to him, not once, but in some cases, several times before he could grasp the significance of the problem or its solution. The situation got very strained in other instances and this fellow was very close to losing his job. As a result of his apparent lack of a good foundation, he was put on jobs where very little thinking was required other than to follow instructions.

Another engineer, from a school equivalent in standing, came to work in our group a few months later. This fellow could be easily taught and was able to grasp situations of a similar nature as those mentioned above and think them out himself with satisfactory and systematic results. This type engineer, well grounded in basic fundamentals, progresses much faster and will, as a result, receive more detailed work and have more responsibility given to him.

Industry is pleased when they receive the latter product because he reaches his productivity "break-even" point earlier and becomes an asset to the company rather than a liability. This is shown by advancements, increases in responsibility, and increases in the monetary compensation which he receives.

Concepts of Fundamentals

First of all, the engineering colleges should teach fundamentals. What are fundamentals? Again defining, "fundamentals are foundations or essentials: a principal law, or article which serves as groundwork of a system."

The following four points might help to visualize the concepts of fundamentals.

1. A knowledge of physical theory equal to the feeling and knowledge of musicians for performance of a musical instrument.
2. Ability to express conventionally such physical theory by words, diagrams, and mathematics as may be desired by the individual or as required by circumstances.

3. Ability to apply such theory in competition.
4. Ability to move among people with a minimum of friction requiring training in convention and principles of sociology and of business and a suitable personality.

Let us spend a few minutes considering each of these.

A musician who is trained properly not only knows his instrument but also knows the fundamentals or essentials of the instrument as well as the music he is playing. He can apply himself to his instrument and to the music he is presenting. The musician can also adapt himself to a piece of music that is of a slightly different tempo, rhythm, etc. An engineer should be so trained that he also knows the fundamentals or essentials of his chosen profession so that he can apply himself regardless of the situation that arises. The engineer so trained has the ground work to progress using these essentials and fundamentals.

Secondly, the engineer should have these essentials so instilled in him that he can express a fundamental or an application of a fundamental that must be used under certain circumstances. These circumstances can vary from day to day and many times during the day. One good example of these varying circumstances is in flight testing. An engineer must be able to conduct a satisfactory program to attain the data needed. At one period of the day he may be called on to conduct a certain test involving engine cooling, while later on in the day he may be required to obtain stability and control data.

Thirdly, all students once they leave college with their diplomas enter into a highly competitive field, where selling of themselves is very important to their advancement. The graduates of our colleges must be so founded that they can apply the theories, fundamentals and basic knowledge when under the pressure of competition. The engineer's foundation can be his downfall. If he is founded on formulas to use here and there, he is soon lost in the sea of competition which may completely engulf him if he gives up.

Finally, an engineer must, shall we say, "work in a laminar flow region," such that he can be among people and move among these people with the least amount of friction. To cite an example, I had to work with about five different groups of people of varying levels of intelligence, ability and environment. Management, engineering, CAA, and the shop as well as my immediate supervisors had to be dealt with and pleased in almost all instances. A person who rubs people the wrong way could start a wave of bad feeling which, of course, would end in making the job much harder and the desired goals more difficult to reach. In meetings, it is very easy to pick out the individuals who can "get along" and those who are always stirring up agitation by side remarks or sarcastic statements.

How can we as teachers instill these fundamentals into our students so they have them available when necessary? I believe that we should mention here the three objectives that we should strive to achieve. These are: 1) develop understanding, 2) learn a skill, and 3) present facts. If the student is presented fundamentals, his understanding of these essentials will deepen and be further instilled in him. With these essentials he then can broaden not only his understanding but also his skill in applying the fundamentals to new and unfamiliar situations. It should be pointed out here that the student should realize what is behind these essentials and why they are especially important to him. This, I believe, can be done by showing the students where these fundamentals were derived, how they came about and the necessity for such a basic structure of fundamentals.

General Applications

Once the fundamentals are presented, general applications should be noted, both by the instructor and by the student. Such fundamentals might be in the form

of the general force equation of aero-hydro-dynamics. The students, by having their thinking stimulated, can cite examples of applications of this general equation in finding lift, drag, thrust, torque and the various other forces on an airfoil, body or propeller. Stereotyped problems should not be presented too often because when the student starts his work in industry and finds a problem that is not exactly like that shown in class, he is at a loss to realize how to proceed in its solution if he doesn't have the groundwork of fundamentals. What are stereotyped problems? In my thinking, stereotyped problems would be those that refer to some specific formula that could be used in each case with little thought required by the student. This produces a static mind and not a dynamic one that must think to solve the problem at hand.

Work should be given to the student that causes him to think. Thought provoking problems should be presented and the student given adequate time to think them out using the tools, fundamentals and essentials at his fingertips. The thought patterns of the student will be developed to a great extent by this procedure. I do not believe that a problem such as this given one day should be answered or worked out by the instructor the next time the class meets. Rather, if the student dosen't have the problem, indicate hints which will help him to study the problem further to its ultimate solution and cause more thought on his part. Another point can be noted here in the use of our textbooks. It will develop our students' thought processes, if the instructor will ask them to explain the progression from, say, one equation to the other. If the student is stimulated by this type of procedure, he will, perhaps, want to know the "why" himself and begin to search, thereby developing himself further. I realize that it is difficult to stimulate the entire class in this manner, but if we can develop a deep interest and stress fundamentals, our students will perhaps begin to approach this end.

Students Should Not Be Spoon Fed

We should not spoon feed students! We should not present formulas and say, "this, this and this are true so all you have to do is substitute and you have the correct answer." This contradicts the previous paragraphs and the student becomes an automaton and essentially a calculating machine. Any untrained person could accomplish such an action.

Here again, let us point out our first example at the start of this paper. This fellow was no doubt of this variety since he could not apply himself because he was definitely lacking in the basic fundamentals. This also recalls a story or definition of a lecture, "The transfer of information from the instructors note book to the students notebook without passing through the mind of either." Let us put a block there so that the material of the lecture will pass through our students' minds and develop them and, if necessary, through our minds as well.

I realize that to accomplish the points set forth in this paper will cause in some cases more work on the part of the instructor, but, if the end result is a higher caliber product, that is our goal and is well worth the extra energy expended.

As a summary to this paper I would like to quote a portion of the Report of the Committee on Aims and Scope of Engineering Curricula in 1952 which contains the following specific objectives for the scientific technological stem :

1) Mastery of the fundamental scientific principles and a command of basic knowledge underlying the branch of engineering which the student is pursuing. This implies:

a) Grasp of the meaning of physical and mathematical laws, and knowledge of how they were evolved and of the limitations in their use; and

b) Knowledge of materials, machines, and structures.

2) Thorough understanding of the engineering method and elementary com-

petence in application. This requires:

a) Comprehension of the interesting elements in situations which are to be analyzed;
b) Ability to think straight in the application of fundamental principles to new problems;
c) Reasonable skill in making approximations, and in choosing the type of approach in the light for solution—in sum, a foundation for engineering judgment;
d) Resoureefulness and originality in devising means to an end.

In the News

Russian has been translated into English by an electronic "brain" for the first time. Brief statements about politics, law, mathematics, chemistry, metallurgy, communications and military affairs were submitted in Russian by linguists of the **Georgetown University Institute of Languages and Linguistics** to the famous 701 computer of the **International Business Machines Corporation.** And the giant computer, within a few seconds, turned the sentences into easily readable English.

A girl who didn't understand a word of the language of the Soviets punched out the Russian messages on IBM cards. The "brain" dashed off its English translations on an automatic printer at the breakneck speed of two and a half lines per second. "Mi pyeryedayem mislyi posryedstvom ryechyi," the girl punched. And the 701 responded: "We transmit thoughts by means of speech."

More than sixty Russian sentences were given to the "brain" altogether. All were translated smoothly in a demonstration performed jointly by Georgetown and IBM as a phase of IBM's endowed research in computation.

A handful of men had been individually engaged in research at various institutions for almost a decade to make a machine convert the meaning of words clearly from one language to another. No practical results were achieved until Georgetown a year and a half ago enlisted the aid of the most versatile electronic "brain" extant, the IBM 701.

This amazing instrument was interrupted in its 16-hour-a-day schedule of solving problems in nuclear physics, rocket trajectories, weather forecasting and other mathematical wizardry. Its attention was turned at brief intervals from these lightninglike numerical calculations to the altogether different consideration of logic in an entirely new and strange realm for giant electronic data processing machines: the study of human behavior—specifically, the human use of words. The result was an unqualified success.

Drawing Division Looks at Future Engineering Education

By DEAN JASPER J. GERARDI, *University of Detroit;*
PROFESSOR F. A. HEACOCK, *Princeton University;*
PROFESSOR JOHN T. RULE, *Massachusetts Institute of Technology;* and
PROFESSOR W. E. STREET, *Agricultural and Mechanical College of Texas,* Chairman

Drawing is the universal method of recording and communicating certain types of information in the engineering profession. Therefore, before an idea takes form or a structure or a machine is built, much informational data must be developed and represented graphically. In years past instruction in drawing placed great emphasis on technique and artistic appearance, and included some training in methods of projection in all four quadrants. Most drawings were inked and much time was spent on well executed lettering. Today drawings are quickly made and well adapted to modern production methods. Drawing courses are improved, keeping pace with the rapid advances in science, industry, and technology. Our industrial success is due in large measure to efficient planning on the drawing board. The more complex the production problem, the more urgent is the need for effective drawings to show the workman exactly what is required. As future progress will depend more than ever upon better working drawings, the drawing teacher today accepts the responsibility of giving engineering students the right kind of drawing instruction, so that the engineer of tomorrow will have the best working knowledge and drafting ability to plan future developments.

Analytical Tool

Nor is it out of place here to state that drawing in all its forms is a foremost instrument in sharpening and deepening the powers of perception which features expanded treatment of the theory of drawing as an analytical tool. Strong emphasis on development of the student's geometrical and spatial ability, to equal his training in equational representation of physical bodies is needed, so that he can interpret shape and position descriptions to those who must construct them. "For working out the shape of objects, visualizing natural phenomena or setting up a basis for calculations, graphics is simple and self-checking. For these purposes, it has no competition and none appears in prospect."—A. F. Puchstein, Consulting Engineer, The Jeffrey Manufacturing Company, Columbus, Ohio.

It is true that many engineers today in responsible positions have draftsmen to make their working drawings from sketches. However, an engineer cannot supervise draftsmen until he becomes proficient in reading and making drawings. Just as the engineer is responsible for the proper functioning of machines and machine elements, he is equally responsible for drawings showing their design, for the selection of correct dimensions, for the proper choice of materials, and many other things which a draftsman has insufficient background training to determine. He must, therefore, acquire the ability to solve new problems in unusual situations, to think creatively, to continue to learn, to remain mentally vigorous, and exercise sound judgment in finding the best answer without loss of

valuable drafting time. In modern industry drawings are considered legal documents, or the basis of contracts, and they must not be misinterpreted.

Modern Reproduction Methods

A large part of engineering costs on any project are involved in making and reproducing drawings. Modern reproduction methods are now being reflected in drafting room procedures. Ink work has been replaced almost entirely by pencil drawings. Freehand sketching is being increasingly emphasized. Stress is placed on the development of an engineering vocabulary. Construction of charts and diagrams and the principles of limit dimensioning have been introduced. Since dimensioning is associated with shop processes and time for shop courses has been curtailed, it is necessary to emphasize what a machine can do and what its limitations are in order to give proper drawing specifications. In descriptive geometry the draftsman's method of analyzing and solving problems by the auxiliary plane method has resulted in students acquiring greater confidence and competence in the use of this science.

Graphics includes in its field all the fundamentals of graphical representation, and of geometrical and graphical analysis. Conventionally, it is covered in most colleges by courses in engineering drawing and descriptive geometry. These courses generally cover graphical processes of solving physical problems, fundamentals of form and design, as well as exact delineation of space objects for recording ideas. Engineering drawing is a subject of high utilitarian value. It is a technique in commercial demand and work on the drawing board is frequently the doorway to promotion. Moreover, for more than 50 per cent of the entering students who do not complete their work in engineering, it is a professional course that offers an opportunity to enter the field of technical employment.

Engineering educators recognize spatial visualizing ability as one of the prime requisites of a good engineer. Recent research by R. R. Worsencroft of the University of Wisconsin and Mary Blade of the Cooper Union indicates that present courses in engineering drawing and descriptive geometry develop this trait in engineering students to a very significant degree over other students, and that following these courses, further development is comparatively slight. This confirms the intellectual value of training in drawing to conceive and create solutions to highly theoretical problems. Drawing introduces the obligation of conforming to standards basically necessary to all engineering practice. It trains to notice subtle differences in quality. It promotes an understanding of form and design, of the feel for various materials and their possibilities. It provides fundamental training for developing creative ability and sound engineering judgment.

Industrial Problems

Careful consideration should be given to the graphical solution of industrial problems, and sufficient time provided for adequate drawing courses in the various engineering curricula. Graphical computation courses including such topics as empirical equations from laboratory data, graphical differentiation and integration, and nomography offer a fertile field for applying graphical methods in fundamental courses such as mathematics, physics, and mechanics. Further, there is a need of drawing courses to bridge the gap of one or more years from drawing to design to provide essential information and give a better carry-over and continuity. Engineering graphics has broader educational functions than developing ability to represent objects by orthographic drawings and to solve space problems by descriptive geometry methods. For graphics is a comprehensive term, including not only engineering drawing and descriptive geometry, but also the advanced courses of kinematics and graphic

statics and other similar courses in the various technological curricula.

It is recommended that drawing teachers be given greater opportunity to participate in or supervise programs which rely on graphics for solution in engineering and scientific research or development.

The value of such research is demonstrated by recent projects applying drawing and descriptive geometry in the treatment of cancer by H. W. Vreeland at Columbia University and in the design of artificial limbs by A. S. Levens at the University of California.

In the News

A fund of $238,500 for grants to universities and colleges to advance the teaching of science has been announced by the **Du Pont Company**. This distinctly new part of the company's program of aid to education is the result of an experimental plan announced last year.

The company has now made advancement of teaching the largest single part of its aid-to-education program, which for many years has also provided grants for fundamental research and postgraduate fellowships. Under the whole program it has authorized a total of more than $700,000 for the 1954–1955 academic year as compared with $600,000 for the present year. In the longer standing plans in the program, the company is granting $230,000 for fundamental research and $222,000 for postgraduate fellowships in science and engineering.

The Sectional Meeting of the **World Power Conference** will take place in Rio de Janeiro, July 25 to August 10. The U. S. National Committee for the World Power Conference is working with the Department of State in organizing the U. S. delegation.

The **Interamerican Association of Sanitary Engineers** has selected Sao Paulo for their meeting. It will take place July 25 to 31. The U. S. delegation is in the process of being formed.

The Third Convention of the Pan-American Federation of Engineering Societies (UPADI) will also meet in Sao Paulo, August 2 to 12. This meeting will attract engineers of all societies from Latin America, Canada and the United States. Engineers Joint Council is currently selecting the U. S. delegates and alternates.

Teaching Tips

The Mechanical Engineering Department at Michigan State College endeavors to "Integrate the work of several courses, and to make the work in these courses meaningful and practical by designing and manufacturing small air compressors on a production basis." The project was initiated by Dean Miller while he was head of the Mechanical Engineering Department as a cooperative project of the design course, pattern shop, foundry, machine shop, and industrial engineering class. It was intended that the students should become intimately acquainted with production tools, their operation and limitations, although it was realized that great skill in these fields could not be achieved.

The compressor was designed by the students in the advanced design classes during the Spring term of 1947. The following Fall the pattern shop and the foundry cooperated in producing first metal patterns for the cast iron parts, and later the iron castings for the compressor. A number of jigs and fixtures had to be built for the machining of the various parts, including a jig for welding the connecting rods which are made of pieces of standard water pipe. All the parts are produced in this department with the exception of the piston rings and bearings which are purchased. The cast iron parts include the flywheel, cylinder, and an alloy iron crank shaft. The piston is an aluminum alloy casting made in a permanent mold. The valves are made of thin stainless steel, and the pressure relief valve of brass.

The machining operations are conducted in the machine shop on a production basis with each part having its own group of tools, doing predetermined operations on it. Sophomore students act as the machine tool operators, juniors as foremen and set-up men, and seniors act in time study, motion study, and other industrial engineering positions. Students who have helped in the production of the air compressors are allowed to buy one each if they wish at the cost of the materials.

Future Trends in Technical Institute Education*

By DR. HAROLD P. RODES

President, Ohio Mechanics Institute

Whenever a person becomes sufficiently foolhardy to predict future developments in any area of human activity, it is apparent that his forecast must be an extrapolation of his past experiences. In this case, the author's work experience has included Industry as well as Liberal Arts, Engineering, and Technical Institute education. The predictions which follow are, therefore, based upon varying amounts and types of experience in these fields:

1. It is anticipated that student enrollment in college curricula of technical institute type will increase. In addition to the obvious reasons, such as larger high school graduating classes and a greater percentage of high school graduates continuing with further education, it is anticipated that many returning service men will find a two-year collegiate program attractive because it will enable them to find full-time technical employment and to establish a normal family life as quickly as possible. More important, however, from the standpoint of increasing technical institute enrollment is the expanding need of industry for training of technical institute type. This involves the addition of curricula in Chemistry, Electronics (particularly Television), Technical Illustration, Industrial Supervision, and Construction in technical institutes which are not already offering programs in these fields.

Transfer Policies

2. The Iron Curtain which has existed between some professional engineering schools and some technical institutes will be gradually removed, so as to facilitate appropriate enrollment and transfer in both directions. You are well aware of the fact that the American Society for Engineering Education and the Engineers Council for Professional Development have taken the lead in developing a close working relationship between the different types of institutions of higher learning which are offering education related to engineering. We are entering a period when these basic policies of transfer which have been agreed upon among the higher echelon of education should be carried out at the level of the person who is most concerned about it, namely the transfer student himself.

By way of illustration, we have been extremely fortunate in Cincinnati to have developed a pattern for such a transfer relationship between the College of Engineering at the University of Cincinnati and the Ohio Mechanics Institute. Although the objectives and, therefore, the content of a technical institute curriculum differ from those of a four- or five-year engineering curriculum, there are certain similarities which should be recognized in a realistic transfer arrangement. On the basis of a conference between department heads of the University and of O.M.I., it was determined that certain courses in chemistry, mechanics, mathematics, engineering drawing, and English were sufficiently similar to justify transfer in either direction. It is now possible for qualified graduates of the two-year technical institute curricula at O.M.I. to receive approximately one year of transfer credit at several four and five-year engi-

* Presented at ASEE Annual Meeting, University of Florida, June 23, 1953.

neering schools. It is likewise possible for an engineering student completing two years of study in a four or five-year engineering school to receive approximately one year of transfer credit at the Ohio Mechanics Institute. It should be emphasized that transfer is a minor function of a technical institute and that we are discussing only a very small percentage of those young men who complete a two-year technical institute program aimed at immediate employment in industry. Nevertheless, we are just as proud of the fact that one of our graduates is on the "Dean's List" at the University of Cincinnati as we are proud of the fact that a boy who completed two years of electrical engineering at Purdue is on the "Honor Roll" in the second year of our two-year Electrical Engineering Technology curriculum. Although the number of transfer students will not and should not increase markedly, I believe that many more professional engineering schools and technical institutes should make it possible for such transfer to take place without either penalizing the student to the extent of compelling him to repeat subject matter unnecessarily, nor on the other hand expecting him to handle the work of the third year in engineering when his two years of technical institute training has not aimed in that direction. In general, the pattern will probably develop into one of approximately one year of transfer credit for two years of either technical institute or professional engineering study.

Greater Recognition

3. We can definitely look forward to greater recognition of the place and importance of technical institute education by Industry from the foreman to the chief engineer, by Education from the elementary school teacher to the university president, and by Parents from Mom to Pop.

The current technical manpower shortage has stimulated Industry to analyze the actual requirements for many technical positions. A number of companies found that they were employing professional engineering graduates in positions for which technical institute training would be more appropriate and, therefore, more satisfying. Several companies have inaugurated special orientation programs for new employees who have been educated in two-year technical college curricula. I believe that this trend will continue to the advantage of both American industry and the engineering profession.

Many counselors and educators, confronted with statistics which indicate that almost half of our high school graduates can profit from some further training at the college level, are beginning to look more and more to those institutions of higher learning which offer a two-year program in preparation for responsible employment in business and industry. As the high school graduating classes become larger and larger, this trend will undoubtedly accelerate.

Mother and Father will always want Junior to go as far in the World as he possibly can. The social prestige of a college education cannot be denied in this day and age. However, as the two-year college graduate with his Associate's Degree finds his rightful place in American industry, Junior will have both the standing and the income which will make Mom and Pop proud of him.

4. The very nature of a technical institute curriculum requires that it be constantly in close accord with the practices of the particular industry which it is serving. One of the best means of accomplishing this is through the cooperative plan of education whereby students have an opportunity to relate the instruction which they are receiving in the classroom and laboratory to actual working conditions on a cooperative job in industry. Therefore, despite the administrative headaches occasionally involved in a cooperative education program, I believe that both the "co-op" technical institutes and the cooperating companies have found such a plan sufficiently satisfying to advocate its adoption by other colleges in other communities. This cannot be accomplished overnight by indus-

trialists and faculty members who are unacquainted with the "co-op plan," but I feel confident that this system will receive wider adoption throughout the nation.

5. The technical institutes are not entirely unaware of the emphasis which is being placed upon general education in contrast to specialized education. If it is difficult to find room for additional general education in a four or five-year engineering curriculum, it is even more difficult to find room in a streamlined two-year curriculum. I predict therefore that, with the exception of certain courses in English and Psychology, the technical institute curriculum will achieve most of the objectives of general education through the teaching techniques employed in its technical courses as well as through good counseling and extra-curricular activities.

Employment Problems

6. The current shortage of technically trained manpower has created certain employment problems in education just as it has in industry. This is particularly true of the field of technical institute education which is necessarily dependent upon a corps of instructors who are not only competent and enthusiastic teachers but who also possess considerable industrial experience. It is extremely difficult in these times for a technical institute to attract to its faculty an outstanding industrial man who is in his thirties, forties or fifties and near or at his peak from the standpoint of income. Therefore, I believe that for the next few years our technical institutes will draw their faculty members from three different groups in order to maintain the high quality of instructional competence and industrial experience which must be represented on a technical institute staff. Although outstanding industrial men in their thirties, forties and fifties may not be available on a full-time basis, those who are genuinely interested in teaching but cannot afford the financial sacrifice may be employed on a part-time basis. Secondly, there are a number of good engineers and prospective teachers reaching age sixty-five who can now afford to teach because in most cases their children are self-supporting and they have only themselves and their wives to support. Our Institution recently added a truly "master" teacher from this category.

In order to balance the maturity of these two categories, there are still some young men in their twenties, fresh out of college with little industrial experience, who have a burning desire to teach and can, therefore, provide considerable assistance in the laboratories and gain some teaching experience in the basic sciences and mathematics.

These are the future trends in technical institute education as I see them. Like all predictions they are subject to the whims of the future, particularly the international scene and the business cycle. Nevertheless, I believe that these six trends hold the significant clues to the future development of technical institute education in the United States.

Modern Engineering Physics from the Viewpoint of an Administrator*

By J. P. ABBOTT

Dean of the College, Agricultural and Mechanical College of Texas

Anyone who is asked to represent a viewpoint should, it seems to me, first make clear the point from which he proposes to do the viewing. If it does nothing else, this should reduce one of the hazards of discussion—the tendency on the part of all of us to proceed from what Justice Holmes called an "inarticulate major premise." Before looking at modern engineering physics, then, I ask you to consider with me the purpose of education. If this seems to you going around Robin Hood's barn to get to the subject, I can only plead that physics as a science and engineering as a profession are too important to the welfare of mankind to be considered solely, or even chiefly, from the point of view of the department of physics or the school of engineering.

For me the purpose of education—whether that of an engineer, a scientist, a business man, or any other—was never better defined than by John Milton in the *Tractate on Education*. "I call therefore a complete and generous education," Milton said in words familiar to you all, "that which fits a man to perform justly, skilfully and magnanimously all the offices both private and public, of peace and war."

In this conception of education, I believe, educators of all persuasions can meet on common ground. It is rigorously practical; in effect it says that education should prepare a man to do whatever he will be called on to do. It is at the same time liberal; it specifies that education shall prepare a man to do what he is called on to do in a manner in keeping with the most generous development of his powers.

There is a special appropriateness in reminding ourselves of Milton's definition whenever scientists and engineers meet to discuss problems of education. This definition was a sort of bench mark for those who helped draft the Morrill Act of 1862, and that Land-Grant Act was the motivating force behind the development of higher education as we know it today in our universities and technological colleges. The language of the Act itself specifically coupled "liberal and practical" in describing the kind of education that was to be fostered. As you know, the American Society for Engineering Education has consistently striven to preserve the marriage.

Major Premise

From this introductory analysis it is easy to move to my major premise as regards physics and the engineer. The engineering student, I submit, should be provided with such a knowledge of physics as he will need to do whatever he is called upon to do. (For the time being I omit any consideration of the manner of the doing, although I shall return to it.) I have encountered no one who is willing to take serious issue with this premise. Unfortunately, however, acceptance of the premise does not mean agreement on a program of action. Indeed, the same

* Presented at the Annual Meeting of ASEE, Physics Section, University of Florida, June 26, 1953, when the author was Dean of the School of Arts and Sciences.

premise is used to support the most widely divergent conclusions.

As I see it, much of the trouble derives from the fact that there is not yet a general agreement as to what the engineer will be called upon to do. After careful study, I am forced to conclude that *engineer* itself is an ambiguous term. It covers many distinct activities, each with a different set of offices to be performed. At one end of the scale there is the technician. At the other end there is the engineer-statesman. And in between there are designers, researchers, managers, constructors, and salesmen. What will best fit a man to perform as a designer will not necessarily best fit him to perform as a manager. A further complicating factor is that the same individual, at successive stages in his career, may be asked to fill the offices of a technician, a designer, a salesman, a manager, and a statesman.

That these facts have implications for engineering education is apparent to some members of this society. Mr. L. E. Grinter, in his "Questions Concerning the Engineering Curriculum" (JEE, January 1952), made them explicit. "The question to be raised," he said, "is whether we can provide the flexibility within individual curricula to take care of the diverse interests of designers, researchers, managers, constructors, salesmen and statesmen."

Physics and the other sciences are involved in this question. Flexibility may not be demanded of all engineering graduates. As Mr. Gordon S. Brown, Professor of Electrical Engineering at the Massachusetts Institute of Technology, put it, "Many [engineers] will be concerned wholly with bread and butter, or cookbook engineering rather than the advancement of technology. A sound education in the sciences is an unnecessary if not an indigestible luxury for a cookbook engineer . . ." (JEE, December 1952).

Some engineering faculty members enter a demurrer at this point. According to them, the analysis I have just outlined stems from an archaic conception of engineering education and simply perpetuates the discredited notion that the undergraduate curricula represent narrow job specialization. They say, further, that what is actually taught in the several curricula is fundamental and adds up to little more than the minimum knowledge necessary for any activity an engineer may have to undertake, whether it be design, research, construction, sales, management, or statesmanship.

Diversity of Careers

I acknowledge the demurrer and my own limitations as a judge. But it seems to me that the weight of the testimony from engineering faculties is as I have indicated. And if I am right, the problem of making our course offerings fit a diversity of careers must be faced, rather sooner than later. Perhaps, as more and more educators are suggesting, Professor Brown's bread and butter engineer should receive his education in a technical institute, with courses in physics, for example, tailored to his probable future needs as the user of engineering cookbooks. But a prior step, I suspect, requires the removal of any onus from this phase of engineering. The cookbook engineer is a valuable member of society, and should be so recognized. As a matter of fact, at least one director of industrial research has told me that the technician often makes a better member of a research "team" than does the professional engineer or scientist asked to serve under one of his fellows.

Leaving the technician aside, it may be that in the long run curriculum makers will decide to redesign engineering curricula to prepare for the functions enumerated by Grinter, rather than according to the traditional categories of mechanical engineering, civil engineering, and so on. Or, perhaps, a curriculum revision will take the direction of assigning special emphasis at certain institutions to the managerial phases of engineering, or to the research phases, or to the salesmanship phases. All these are possible, and each would modify a college administrator's viewpoint concerning engineering physics at his institution.

But there is another possibility which seems to me more promising. It stems from a growing recognition that in their more professional phases all the accepted divisions of engineering are moving closer to each other and to the basic sciences. Any reader of the *Journal of Engineering Education* is aware of the reiterated argument, in which men of diverse professional interests echo each other, for more basic science in the engineering curricula. One of the most persuasive spokesman is, as you know, Mr. S. C. Hollister, Dean of Engineering at Cornell University.

In an article entitled "Looking Ahead in Engineering Education" Dean Hollister said this: "It is clear that we cannot delineate sharply the various techniques that will be in use twenty-five years or fifty years from now; but it is certain that the principles on which these technical developments will be based are principles which are now available in the basic sciences. *Our problem, then, is to strengthen the basic science content of our curricula*" (JEE, December 1952).

Dean Hollister, like Milton, is concerned with fitting the engineer to perform offices not currently contemplated but almost certain to be thrust upon him. He has support from another source with an argument of more immediately practical impact. It comes from industry, where most engineers will be called on to fill whatever offices their lives will exact of them. Two quotations will document my point.

In the first Mr. Robert C. Sprague, President of the Sprague Electric Company, put it this way: "As an employer of more than 100 graduate engineers, I am among those who hold that the education of tomorrow's engineer should stress the basic sciences, even if this can only be done at the expense of applied engineering subjects." Mr. Sprague's reason is also, I submit, in keeping with the general principle I borrowed from Milton. "From my own observation," he goes on to say, "I find dramatic evidence that the man with the strongest basic training has the greatest adaptability. Because the basic sciences can be applied to different problems in many branches; or to a single problem which may extend into overlapping branches. In the rapidly changing technological industries such a man enjoys a tremendous advantage" (JEE, April 1953).

Fundamental Courses

The second quotation, similar in import, answers the strongest objection I have encountered to the increase of emphasis upon the basic sciences. It is from an article unequivocally entitled "The Modern Engineer Should Be Educated as a Scientist" (JEE, December 1952). The article is by Mr. Harry K. Ibrig, Vice-President in Charge of Research, Allis-Chalmers Manufacturing Company. In Mr. Ibrig's words, "It is often said that fundamental courses are all right for large companies that have training programs, but that small companies require engineers trained in specialties so that they can start work at once. One of the members of [A University Cooperating Committee of the Wisconsin Society of Professional Engineers] is a mechanical engineer who owns a small company manufacturing mechanical equipment. He believes that a broad fundamental training is very important in a small company where the engineers have to be versatile because the company cannot afford an engineer for each specialty."

It is clear to you by this time that my own idea of a generous education for the engineer is one that stresses the basic sciences, among which physics with its sibling mathematics is perhaps the most prominent. And my reason is that the emphasis upon basic science seems to me more likely than any other to fit an engineer to perform at least skillfully if not also justly and magnanimously the principal offices he will be called upon to fill.

I am, naturally, not alone in this belief. Indeed I would be reluctant to advance it so boldly if others had not also arrived at the same conclusion. There is a clear acknowledgment that physics deserves

larger place in engineering education in the "Report of the Committee on Adequacy and Standards of Engineering Education" of the ASEE (JEE, January 1952). As the report says, "The time requirement in physics has remained nearly constant in most curricula since about 1885. Generally the classical approach to physics instruction has been followed . . . the approach from the point of view of atomic and molecular structure is needed but wanting."

What the time requirement should be I am not prepared to say. The Wisconsin Committee referred to by Mr. Ibrig has said that it is "very desirable from an industrial standpoint" to set the requirement at 33 hours in a total program of 144 hours. Since this is precisely the requirement set for all engineering subjects, I take it that this represents an extreme position and one not likely to be adopted by engineering schools in the foreseeable future.

My friends in the physics faculty of my own institution are more moderate. They believe that a time requirement of approximately 16 semester hours may be enough. In this time, they say, an engineering student can be led to understand the fundamental concepts of classical physics—dynamics, wave motion, heat, sound, light, and electricity, and can also be led to understand the extension of these concepts into the realm of atomic and nuclear phenomena. They are convinced that with this conceptual foundation the student can, if he will, carry his own education forward in whatever area of physical effects his duties may place him.

But at this stage of the discussion concerning the engineering curricula, it is probably premature to talk of semester hours. A more fundamental question needs to be answered first. Mr. W. S. Evans, Professor of Civil Engineering at the University of Maine, asks it in the April issue of the *Journal of Engineering Education:* "Are We Ready to Consider a Major Change of Policy?"

Curriculum Hours Limited

His own answer is that "we should hold the four year curriculum for those things which can best be taught in an institution of higher learning." This answer assumes, of course, that we will reject the possibility of extending the engineering program to five or more years. From my own observation I am convinced that in the majority of institutions the four-year pattern will continue to prevail. I do not know whether our schools of engineering are ready for Professor Evans' major change of policy. Since it will entail a complete revision of hallowed curricula and since I have great respect for the laws of inertia, I am inclined to think that any change will come slowly and in piecemeal modifications of existing course offerings. Professor Brown, whom I quoted earlier in this paper, recognizes that a knowledge of atomic physics and physics of the solid state is important to modern engineers. "But," he adds immediately, "the curriculum hours for teaching physics are limited."

Even with a fairly extensive revision of engineering curricula, increases in the amount of physics required of engineering students will almost certainly have to be accommodated to limitations of curriculum hours. Professor Brown suggests that a possible solution may be to turn over the teaching of much of the classical physics to engineering departments, where it will become an integrated part of engineering. This would leave the department of physics room to introduce a solid body of work in modern physics. The suggestion is certainly worth considering. The consideration, however, should be by both the physics and the engineering faculties, and they should be cautious of stopping short before they reach a consensus.

If the parenthesis is needed, let me say that I am not implying that departments of physics should necessarily be assigned more of the engineering student's time, but only that the conceptual bases of physics should be given a larger

place in his education. It may be true, as I am assured, that engineering courses are for the most part simply applications of physics and fundamental in nature. I am willing to accept the assertion that it is difficult to segregate physics and engineering, and to grant that it is special pleading to argue that the physics in a physics course is a basic science but the physics in an engineering course is not. But I do believe very firmly that physics, wherever taught, loses value for the student if its applications are permitted to obscure its concepts. And that is why I would have the physics and engineering faculties mutually agree upon a division of labors.

With this observation I reach a transition point in my survey. I have declared my conviction as a college administrator that engineering students, if we exclude those who aim at being hewers of engineering wood and drawers of engineering water, should be provided with a solid foundation in the basic sciences, among which I assigned a prominent place to physics, including the physics of atomic and nuclear phenomena. I based my case on the argument that such a foundation is the best assurance that the engineering graduate will be prepared to perform skillfully whatever duties he is assigned as a professional engineer. It remains for me to consider engineering physics in terms of Milton's other adverbs—*justly* and *magnanimously*.

Specialized Technical Competence

It may well be false to say that the engineer concentrates on developing specialized technical competence at the expense of all other considerations. But to the extent that it is true in any student's case, he has denied himself a generous education. "Born a man, died a chemical engineer," is a tragic epitaph, but no more tragic than "Born a man, died a physicist," or for that matter no more tragic than "Born a man, died a college dean." Even a moderate amount of specialization makes us subject to a common hazard of the times. Matthew Arnold described it in *Culture and Anarchy* when he said, "Faith in machinery is our besetting danger." We tend to put our faith in the machinery which we have seen operate successfully in our own areas of competence. And by extension of this understandable attitude, we tend further to put our faith in machinery itself. It may be the atom bomb; it may be a loyalty oath; it may be statistics; it may be this or that system in this or that sphere. In our discussion here it may be one curricular pattern rather than another. Faith in machinery of any kind is fatal to achieving the sort of education Milton defined. That education aims at making a man capable of taking all machinery in stride. Knowing that he may be confronted with a new model tomorrow, he is safe from idolatry of the current model.

I see, or think I see, a disposition on the part of many of us to put our faith in a piece of machinery which I personally admire very much. Mr. Irving S. Olds, recently retired U. S. Steel Board Chairman, puts it this way: "The most difficult problems American enterprise faces today are neither scientific nor technical but lie chiefly in the realm of what is embraced in a liberal arts education." As one whose formal education was nurtured in the liberal arts, I am happy that their place should be recognized and their estate acknowledged to be honorable. And I recognize the significance for the student engineer, who may someday be asked to assume managerial functions, of the warning issued by another industrialist, Mr. Sidney Swensrud, President of the Gulf Oil Corporation. Mr. Swensrud has said, "The men who come into management must understand the whole sweep of modern political, economic and social life." But I would be less than scrupulous if I did not warn all who are about to put their faith in a liberal arts education that it too is a machine, that its faculty may err on the side of idolatry like any other faculty, and that any model of it is subject to obsolescence.

It is obvious that some machines are better designed to achieve their purposes than others. I myself am convinced that our educational machine in engineering has neglected what the liberal arts could add to its efficiency of operation. But I would not have us substitute one machine for another in blind faith.

Like the drafters of the Land-Grant College Act, we would do well to return to our bench mark. Milton's definition makes no mention of any particular system of education. It favors no one discipline. It declares only that whatever system will prepare a man to do what he has to do in a fashion commensurate with his highest potential is a complete and generous education. This education, it says further, is *one*, not a compromise among competing systems or branches or divisions.

This sort of education has been prophesied for engineering. Last September at the Chicago Centennial of Engineering in a Symposium on Engineering Education and Training, Dean L. M. K. Boelter of UCLA made this prediction in his paper "Looking Ahead in Engineering Education": "Throughout the engineering educational process the complete growth of the student will be facilitated with the teacher as central. He will be encouraged to 'know himself,' to know others (and society), and to be a living example of the interrelationship between the physical and human worlds. For the student there cannot exist two stems (technical and social-humanistic) but rather a synthesis not only of the knowledge of the physical world but of knowledge itself" (JEE, December 1952).

May Take Several Shapes

As I have indicated, what shape the curriculum will take is as yet undetermined. It may, indeed, take several shapes. I think it is almost certain that physics will be given a larger place in every pattern. Physics will be judged, however, not alone by what it contributes to the skill of the student engineer, but also by what it contributes to his total development as a person. I think it can be made to contribute much.

In company with mathematics, the other sciences, and many of the engineering subjects themselves, physics can induce in the student an abiding respect for facts. This alone is a great contribution toward the student's full development. Respect for facts is essential to an apprehension of truth. As Mr. T. V. Smith, Maxwell Professor of Citizenship at Syracuse University, has said, "Science . . . is the one great organized, established way that the human race has found of developing scrupulosity in human beings." Scrupulosity, he goes on to say, is not an inherent quality. "It is an achieved capacity, for most of us would not know truth if we met it in the road. Yet we need people who know how to get it when we do need it; and that is the role of science" ("Middle-Sized Values for Higher Education," *Current Issues in Higher Education,* 1952).

The peculiar contribution of physics to the generous education of the student engineer, I am convinced, lies in its power to initiate him in the use of the mathematical instrument. This instrument, as A. d'Abro wrote in *The Evolution of Scientific Thought,* is capable of "giving us a deeper insight into the problems of nature, revealing unsuspected harmonies and extending our survey into regions of thought whence the human intelligence would otherwise be excluded."

As the student of physics proceeds from concept to concept, he can be led to see, in d'Abro's words, that "in order to render nature amenable to mathematical treatment, it is necessary that we should succeed in reducing the various natural phenomena to common terms." He can be led to the realization that usable knowledge begins with "seeking differences of quantity beneath differences of quality." Although I am not competent to carry the analysis to a rounded conclusion, I submit that the student who learns this lesson is well on the road toward preparing himself for the just performance of his duties whatever they be.

If it is to do these things, of course, physics must be properly taught, with a view to harmonizing its own peculiar contribution with the contributions of the other disciplines, to the end that the student's education will be an organic whole and not a collection of bits and pieces of knowledge. As Dean Boelter said, the teacher is "central." As a college administrator I can only deplore the attitude of some members of the physics faculty in many colleges. They regard the teaching of the basic undergraduate courses as a chore and their assignment to such courses as an imposition. The basic courses deserve the best possible teaching by the finest members of the physics staff. No physics faculty known to me would feel that it had carried out its responsibilities if its instruction aimed at developing in the student no more than an *ad hoc* knowledge of physical concepts and manipulative skill in their application. And every physics faculty, I think, would acknowledge that courses in physics should contribute to the student engineer's growth in habits of scrupulosity and devotion to truth. But how many direct their best efforts to this end? How many simply assume that the benefits will accrue automatically from contact with physics in the classroom? How many deliberately aim at making the basic physics courses a liberalizing experience? Only with the most devoted teaching can physics, or any other subject, become part of a generous education.

Conclusion

This completes my survey of engineering physics. The view has possibly been more panoramic than you would prefer. It is my hope, however, that if I have failed to bring new vistas to your attention, I have at least not fogged the landscape. All of us are seeking the same end, whether we orient ourselves on Milton's definition or not. That end, I take it, is to make every course contribute as fully as possible to the complete education of the student. If we keep that end in sight, our differences will become the means of exploring the alternative avenues of approach.

College Notes

Dr. John D. Ryder, head of the electrical engineering department at the University of Illinois, has been named Dean of the School of Engineering at **Michigan State College.** The appointment is effective July 1, 1954. Dr. Ryder succeeds Dean Lorin G. Miller who retired July 1, 1953. Dean Miller, a member of the staff since 1929, had served as dean since 1949. Following Dean Miller's retirement, Dr. A. A. Potter, retired dean of the School of Engineering at Purdue University, has served as consultant to President Hannah in charge of the School of Engineering.

The Undergraduate Course in Process Design

By CHARLES A. WALKER

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Introduction

The instructor charged with the responsibility of teaching a course in process design to senior students in chemical engineering is faced with a serious problem in determining how the students' time can be utilized most effectively. The problem is particularly difficult in this course because of the breadth of the subject of process design, embracing as it does the fundamentals of chemistry, thermodynamics, unit operations, reaction kinetics, economics, instrumentation, etc. In view of the breadth of the subject it is not surprising that there exist widely divergent opinions as to the proper method of approaching the subject. As a matter of fact, it is undoubtedly true that there exist several satisfactory approaches to the subject, some of which will be effective in the hands of a given teacher and some of which will not.

It would be very helpful in planning the process design course if it were possible to state clearly the objectives of such a course. However, since process design is usually taught as a course requiring the student to bring to bear on a particular problem his previous knowledge of science, engineering and economics, the objectives of the process design course become identical with the overall objective of the engineering portion of a student's education. One way of stating this overall objective is to say that we attempt to develop in students the ability to apply to certain types of problems a particular type of reasoning process, having its origins in mathematics and the physical sciences but going beyond these because some of the problems require reasonable answers to be obtained in the absence of sufficient knowledge for a precise analysis. When a student enters the process design course he will have had a considerable amount of training in the solution of problems where precise analysis is possible. His approach to these problems will have been directed to a considerable extent since most of them will have been assigned to amplify certain well-defined lecture material or certain well-defined reading assignments. The student at this point is ready to learn several facts about the practice of the profession of engineering:

1. The practice of this profession does not consist merely of solving problems which have been stated by higher authorities but of stating as well as solving problems.
2. It is the engineer's responsibility to determine which portions of the available knowledge can be applied to a given problem and whether a precise solution to a given problem is feasible; i.e., to recognize when precise analysis must be abandoned in favor of approximation.
3. Some problems in engineering are so complex as to necessitate rather arbitrary decisions on how to proceed with a solution to the problem. Such arbitrary decisions may be completely justified when there are relatively minor differences in the methods of solving the problem.
4. Most engineering achievements of any magnitude are the result of cooperative efforts, frequently involving large numbers of scientists and engineers.

In process design as in no other course in the undergraduate curriculum there exists the opportunity to broaden the student's perspective and to indicate to him what he must do in order to become a successful engineer.

The time available for doing these things is limited, however, to about 150 working hours for a one-semester course or possibly 300 working hours for a two-semester course. Thus we have in the best case the equivalent of no more than eight 40-hour weeks to devote to this very important portion of the student's education. This appears to be totally inadequate in view of the further fact that this material can hardly be taught; it must be learned. It is not argued that more time should be devoted to this course but rather that the instructor must utilize the students' time very effectively.

The Scope of Process Design

The primary task of a process design engineer is one of synthesis, of bringing together the knowledge and opinions of scientists, engineers, economists and others and applying them to the problem of designing a plant. He is not merely one who accepts such knowledge and opinions in predigested form. Instead he must work closely with these other groups in building up the required knowledge, making certain that research and development groups provide the essential data for process design and frequently, because of economic considerations, making certain that they provide no more than the essential data. It is also his task to analyze all data and all opinions critically since he has the ultimate responsibility of applying these in such a way that a workable design results. These several functions place the process design group in a key position, acting sometimes in an advisory capacity and again assuming the major responsibility.

Consider that the statement of a problem in process design must be developed over a period of months or years as the result of the activities of several groups of people. Thus in the development of a new product the following steps might be involved:

A. Survey of literature
B. Survey of markets
C. Basic research and development
   1. Choice of a process
   2. Raw materials specifications
   3. Product specifications
D. Preliminary layouts, cost estimates, etc.
E. Plant location
F. Plant layout
G. Final design and economic analysis
H. Plant construction
I. Plant start-up
J. Plant operation

One usually conceives of such a development as occurring essentially in chronological order and involving shifts in responsibility from research to development to design groups. This picture is essentially correct but there is also involved a great deal of cooperative effort, and many of the activities listed occur more or less simultaneously.

For example, the process design group may be called on to examine a project after the surveys of literature and markets are completed. There may be enough information available from these two sources to permit a preliminary design and cost estimate. The results of this preliminary design and cost estimate may indicate that the proposed project is not economically feasible, in which case it would not enter the research and development laboratories. If the process appears to be feasible at this point it is apparent that the process design group can perform a very important function in advising the research and development groups as to which portions of the process require further investigation. As research and development proceed it may be necessary for the process design group to evaluate their results periodically, advising whether a particular method of

attack should be continued or not, advising when the data are adequate, etc. This may be one of the most difficult tasks of a design engineer since considerable diplomacy may be necessary in explaining to a development engineer that one of his pet ideas is not economically feasible. For example, if the equipment for a particular process is available for a price of $100,000, it would be difficult to justify a $25,000 development program in the hope of reducing this cost to $60,000 unless the problem is one which might occur frequently in the future, no matter how ingenious the proposed solution might be.

It is to be noted that during steps A, B and C of a development such as that outlined above the function of the process design group is an advisory one. It is not intended to imply that all of the work done by research and development groups is subject to appraisal by the process design group since the engineers and scientists in these former groups have much broader functions. After the first three steps of the development are completed, however, the process design group assumes the major responsibility for the plant location and layout, final design, supervision of construction and plant start-up.

In many cases the responsibility of the process design group ends when the plant is operating satisfactorily and operators have been adequately trained. This group may be called back to other problems, however, if economic conditions lead to the necessity for production above the design capacity, for the recovery of by-products, for changes in product specifications, etc.

The breadth of activities of a process design engineer may also be indicated by noting that he may spend a large part of his time in stating problems rather than in solving them. The definitions of the problems which may be of interest to the process design engineer may be summarized as follows:

Problem type	Raw materials	Process	Products
1	Unspecified	Unspecified	Unspecified
2	Given	Unspecified	Unspecified
3	Unspecified	Unspecified	Given
4	Unspecified	Given	Given
5	Given	Unspecified	Given
6	Given	Given	Given

The very broadest problem with which a process design engineer is concerned arises when an organization has capital to invest in a chemical enterprise and seeks advice as to product, process and raw materials (Type 1). It is probably more frequently the case that advice is sought as to how to utilize a given raw material (Type 2) or how to manufacture a given product (Type 3). It may also be the case that a desirable product and process are known and the problem is one of choosing appropriate raw materials (Type 4), or that the raw materials and products are specified but the process remains to be chosen (Type 5). Before a final design can be undertaken it is necessary that the varied activities of several groups be so coordinated that the problem becomes completely defined (Type 6) as to these three factors.

The varied activities of a process engineer, as depicted briefly above, make this type of position one of the most thoroughly fascinating ones in the field of chemical engineering. As in all other cases, reaching a position where the full challenge of the field is met requires an apprenticeship in each of the several phases noted. These apprenticeships will cover a period of several years before the full-fledged process design engineer emerges. The decision of the individual student as to whether he should enter this field depends on an honest appraisal of his abilities, interests, physical stamina, ability to work under pressure (or to "think on his feet") and personality characteristics.

Methods of Teaching the Process Design Course

The process design engineer has been depicted as one who must understand all phases of a chemical development, functioning at times in an advisory capacity, and assuming active charge of the project after the cooperative efforts of his own group and the research, development and management groups have stated the problem clearly. It may be noted that a somewhat similar picture could be painted of the activities of the research and development groups since each of these groups functions in an advisory capacity both before and after the major responsibility has passed its particular interests. It is in the process design course that there exists the best opportunity to indicate to students the roles played by each of these groups, thus making the course of great value to the individual student whether or not he enters the field of process design. Perhaps one of the most common failings of young engineers is a failure to appreciate the contributions made by groups other than the one with which he is associated.

We are obviously now in a position to say that the process design course preferably consists of a project in miniature, carrying a process through all phases of its development from the market survey to the final design. The course is taught in just this way at several schools, the students devoting their attention first to literature and market surveys, then to research and development work in the laboratory and finally to the detailed design. This type of course is undoubtedly very effective in the hands of an inspiring teacher and represents a logical approach if sufficient time is available for it. However, it has been noted above that the time ordinarily available is no more than the equivalent of eight 40-hour weeks of student time. In order to obtain definite results in this short period it is necessary that the process chosen for the work be quite simple or that the instructor guide the entire development rather carefully. If the process chosen is too simple the students are likely to lose interest rapidly; if it is too complex their interest will wane because too many approximations will be necessary. If the instructor guides the work too closely the students lose the opportunity of using initiative. Thus for this type of course to be successful the problems must be chosen with extraordinary care, and the instructor must be very careful in his guidance of the work.

The author is inclined to favor a second type of design course which may be said to consist of developing the complete statement of a problem together with a partial solution. If the goal of a complete problem solution is abandoned in favor of this approach it becomes relatively easy to devise problems which preferably have the following characteristics:

1. The statement of the problem is very broad, requiring that the students restate it and amplify the statement as they proceed.
2. Some portions of the problem are such that precise analyses are possible.
3. Some portions of the problem are such that precise analyses are not possible but approximations can lead to adequate solutions.
4. Some portions of the problem are such that neither precise analyses nor satisfactory approximations are possible in the absence of further experimental data.
5. The process on which the problem is based is sufficiently complex that the student's interest is held throughout the course.

A particular problem used by the author in teaching the process design course will serve to illustrate the basic philosophy used. The problem may be stated as follows to the students:

We have been requested by the management of Sachem, Inc., to provide a preliminary report on the design of a plant for the chlorination of methane. The client has available a satisfactory source of natural

gas (typical analysis: 92.1% CH_4, 1.9% C_2H_6, 4.5% C_3H_8, 1.5% C_4H_{10}) and is in position to purchase chlorine from an adjoining plant. We are informed by the client that his market survey group has estimated that there would be a market for the following annual sales of the products of this plant: 1000 tons CH_3Cl, 1000 tons CH_2Cl_2, 3000 tons $CHCl_3$ and 5000 tons CCl_4.

For the preliminary report we may consider that our task is one of developing a complete flow sheet, designing those portions of the equipment where adequate data and calculation method are available, and making recommendations as to the general problems which must be solved in the laboratory before a final design is undertaken. This will be sufficient information to permit us to make very rough estimates of the costs involved.

The students are required first to survey the literature for methods of carrying out the reaction between methane and chlorine. A class discussion following this survey leads to a somewhat arbitrary decision to proceed with the design on the basis of a particular type of reactor but it is emphasized that this decision is subject to review at a later date. The students are expected then to recognize the existence of the following specific problems:

1. Either the natural gas must be purified before chlorination or a very complex mixture of chlorinated hydrocarbons must be separated after chlorination.
2. The estimated sales volumes indicated are subject to considerable error and to constant changes with varying market conditions.
3. In view of the indication in (2) and of the fact that a group of consecutive reactions is involved it will not be possible to adjust the methane-chlorine ratio in the feed to yield a product stream containing only hydrogen chloride and chlorinated hydrocarbons. Either an excess of chlorine or an excess of methane must be used.
4. There will be numerous schemes for the separation of the products of reaction.

The answer to the first problem above is obtained readily when the removal of ethane and higher hydrocarbons from the feed by absorption is compared with the task of separating a complex mixture of chlorinated hydrocarbons by rectification. There are available adequate physical data and calculation methods to permit design of the absorption equipment. The answer to the second problem above lies in a close study of the variables which determine the product distribution. It is not feasible in the undergraduate course to design the reactor system completely but it is possible to decide on the reactor arrangement and to calculate material balances and heat balances. The reactor will have to be "blocked in" for the purposes of a flowsheet unless the instructor desires to guide the calculations carefully. The answer to the third problem lies in a comparison of the difficulty of separating either unreacted chlorine or unreacted methane from the product stream. There are sufficient data and calculation methods available to obtain reasonable answers to the problem of designing the equipment for the separation of products although the students will need some help in calculation methods.

The result of several weeks of work by the students on a problem of this type will be a preliminary flow sheet with complete heat and material balances, with a few pieces of equipment designed at least to the extent of sizing them, and with a few problems stated as needing laboratory investigation. The students will have come to recognize something of the difficulty of stating a problem and they will have used precise analyses in some cases and approximations in others. Most of all, they will have realized something of the spirit of process design.

Finally, there remains the possibility of teaching process design from the other end of the development scheme; i.e., by giving the students a completely formu-

lated problem in which their task is the final layout and design. The author has tried this approach and found it interesting and instructive. It is, however, more difficult to hold the students' attention because of the numerous rather minor details which must be considered. Furthermore, this type of problem is likely to lead students to the conclusion that process design is a field for the patient ones whereas it actually involves so many factors other than final designs that it should be appealing to several types of students. There will be some teachers who feel that this type of course offers excellent training in discipline because of the numerous details involved. Actually, of course, any problem of sufficient scope will offer such training.

Conclusions

There have been presented the author's viewpoints as to the proper nature of the process design course for seniors in chemical engineering. The teaching method suggested is, however, only one of at least three logical methods of teaching the subject. A critical examination of these three presentations of the subject will reveal that the objectives of the process design course can be achieved through any one of them provided that the problems are properly stated and that the instructor provides only the minimum guidance necessary in developing the problem statement and solution.

Perhaps the most important points in the author's presentation are:

1. Process design should be presented not as a drafting table enterprise but as an enterprise involving many factors and requiring that the engineer be not only technically proficient but also skilled in the art of personnel relations.
2. The interest of the students can be held more easily if the goal of a complete and detailed design is abandoned in favor of problems involving the development of a complete statement and a partial solution to a problem.
3. A considerable part of the course should be devoted to the devising of a flow sheet and to analyzing problems to determine where precise analysis is possible, where approximation is necessary and where research or pilot plant programs should be considered.

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Graduate Education in Engineering

By WILLIAM BOLLAY

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A. Introduction

The question of what type of graduate education is of most benefit to an engineer may be approached by reviewing briefly the history of engineering during the past twenty years. More specifically, I shall confine myself to aeronautical engineering. It has been my own experience during this time that the only engineering courses which have been of any use to me have been the courses dealing with the basic engineering sciences. Everything we learned in highly specialized courses in various phases of engineering has been rapidly obsoleted by new developments. The biplane truss design has been replaced by monococque wing design; the reciprocating engine has been replaced by the gas turbine; the wooden structures have been replaced by dural, steel, titanium and glass cloth laminates; the manual controls have been replaced by hydraulic, electric or pneumatic servos and gyroscopic autopilots. Thus, the proposal which I should like to make is that the primary emphasis in graduate, as well as undergraduate, education in engineering should be devoted to teaching the engineering sciences, thoroughly and clearly, illustrating the principles by application to modern engineering systems, demonstrating the principles with simple laboratory models, and giving the student practice by realistic design problems. It is my belief that since the time available in post graduate education is limited to, at the most, two or three years, the time devoted to highly specialized and applied courses should be restricted to a minimum. These specialized subjects should be preferably taken as extension division courses after the student is engaged in engineering practice and has a need for specialized knowledge dealing with his type of work. It is my belief that the detailed design tricks can best be learned by an engineer after he is engaged in a given field, and that the so-called "art of engineering" or the design of a complicated engineering system cannot be taught in the limited time available in school without slighting the essential engineering sciences. This "art of engineering" would therefore be acquired as the result of engineering practice by building upon a sound foundation of the engineering sciences.

B. Aeronautical Developments

Let us review briefly the history of aeronautics during the past twenty years in order to illustrate the above ideas.

(1) Aircraft propulsion

The increase in airplane performance during the past twenty years has been largely paced by the development of powerful and light aircraft propulsion systems. Table I shows the relative performance of typical high performance powerplants of 1933 and 1953. University courses in aircraft powerplants in 1933 were of little help in the design of centrifugal or axial flow compressors or the burners for gas turbines or the combustion chambers for rockets. These new propulsion systems were developed largely by the application of aerodynamic prin-

TABLE I

RELATIVE PERFORMANCE OF AIRCRAFT PROPULSION SYSTEMS WEIGHING 2,000 LBS.

Year	Type	Max. Aircraft Speed, V	Thrust, F	Thrust Horse-Power, $P = \frac{FV}{550}$
1933	Reciprocating Engine and Propeller	V = 450 ft./sec.		1,000 H.P.
1953	Turbo Jet	V = 1100 ft./sec.	F = 6000 lbs.	P = 12,000 H.P.
	Rocket	V = 5500 ft./sec.	F = 100,000 lbs.	P = 1,000,000 H.P.

ciples to the design of compressors, burners, and turbines. The basic laws of thermodynamics and heat transfer, of fluid dynamics and elasticity were of much greater help in the design of these systems than the prior art in the field of aircraft engines.

(2) *Aerodynamics*

With the increase in power, aircraft and missile speeds have increased about tenfold during the past twenty years. The biplane with its external bracing was replaced by mono-planes with streamlined cowlings, retractable landing gear, laminar flow wing sections, and more recently, by the thin swept back wings or delta-wings with a capability of flying at transonic speed and supersonic speed. The traditional aerodynamics courses of 1933 offered little help in the solution of these problems. They presented a summary of past experiences on lift, drag, and pressure distributions on various bodies for an incompressible fluid. Only a few exceptional universities offered courses in hydrodynamics covering the basic theory of boundary layers and turbulence, the theory of wings including low aspect ratios, the fundamentals of gas dynamics including transonic and supersonic flows. Very few aerodynamics courses included rotary-wing aircraft or the theory of wing flutter or the dynamic analysis of aircraft systems.

(3) *Aircraft structures*

With the increase in aircraft speeds, the aircraft structures have also changed radically. In 1933 the most common aircraft structures were of a wood or steel framework and a doped fabric skin covering. At about this time the monocoque or shell structures were introduced. The standard aircraft structures courses were rather inadequate for dealing with the problems of buckling of flat and curved panels in bending, compression and shear. The theory of elasticity including the theory of shells and plates on the other hand, offered a good background for tackling these new problems. Present thin aircraft wings are almost solid plates with swept-back or delta shaped plan forms. The analysis of these wings particularly from the dynamics and flutter standpoint, represents one of the current challenges of structural design. Again, the only tool for the young graduate in this field is a good understanding of the fundamentals of elastic theory and dynamics. The new types of structures currently under study for use at the high temperatures of supersonic flight—glass-cloth laminates or ceramic structures or combinations of these with metallic structures—will require an understanding of the elastic theory as well as of heat transfer and thermodynamics.

(4) *Aircraft system engineering*

The above mentioned examples are illustrative of the type of problems faced by the aeronautical engineer during the past twenty years and now being faced for the future. It was found by experience that the descriptive courses in various phases of aeronautics might help a

young engineer in his first years of industrial practice. They did not equip him, however, with the tools for starting out on a fresh approach.

The most serious problem which is encountered in a modern aeronautical engineering department is the scarcity of engineers with a good background in the various basic engineering sciences. They will ordinarily have studied a limited field like aerodynamics or propulsion or structures, or radar, or servo-mechanisms. However, there are very few with a good understanding of the fundamentals in all of these fields. As a result, the "systems engineering" which means making the compromises between these various elements is usually not carried out too well. This "systems engineering" which is what is sometimes called the "art of engineering" can not be taught without teaching first the engineering sciences. A graduate who has a thorough grasp of the engineering sciences basic to his field of activity will be able to develop the "art of engineering" simply by applying his common sense.

C. Engineering Science vs. Physics as Preparation for Engineering

It has been argued by some educators that the best graduate preparation for a career in engineering is graduate study in physics, chemistry and mathematics. It is my impression that an outstanding young physicist can learn to tackle engineering problems just as an outstanding young engineer can learn to solve problems in physics. However, there is a considerable difference in emphasis between the engineer and the physicist or the mathematician in his outlook and his approach to a given subject. For example, a classical physics text on dynamics presents the basic theory of vibrations of systems with various degrees of freedom. An engineering study of vibrations starts from this point and illustrates how it is possible to reduce complicated physical problems such as the forced vibration of an engine crankshaft, or the flutter of an airplane wing or the vibration of a turbine blade to simplified differential equations which can be solved by approximation methods or with the aid of analog or digital computers. Similarly, a classical physics text on hydrodynamics contains the mathematical theory of fluid motions. An engineering study of hydrodynamics takes this same theory as a starting point but concentrates on the application to wings and airfoils, to skin friction and turbulence, to shock waves and boundary layers. Similarly different viewpoints apply to the theories of elasticity, electricity, and magnetism.

We may approximately summarize this situation by stating that the standard physics courses and texts concentrate on developing the fundamental principles of physics and stating them in a simple mathematical form, that the engineering science courses and texts concentrate on the applications of these principles and equations to engineering problems. Thus, to the physicist, elegant methods of deriving and summarizing the equations (such as vector, tensor, and matrix methods in elasticity, or Lagrange's equations and Hamilton's principle in dynamics) are of considerable importance. To the engineer the principal problem is to reduce a very complicated physical situation to a simplified model, which he can think through and understand with the aid of the mathematical equations and which he can analyze with the aid of simple approximations with the aid of digital or analogue computers, or with the aid of model tests and experiments. Obviously, there is a considerable region of common interests. The best physics texts such as, for example, Sommerfeld's series of books on Theoretical Physics, cover much of the same ground as books or papers on the engineering sciences by von Karman and Prandtl, Timoshenko and Den Hartog, Biezeno and Grammel. It is my belief, however, that courses in physics are not a substitute for the related courses in the engineering sciences but rather, a supplement and that therefore, the engineering sciences should be taught as such by "engineering scientists"

who know the practical problems of engineering as well as the applicable basic sciences.

D. Recommended Program of Graduate Courses

I have attempted to think through the kind of a graduate program of courses I should like to take if I had the opportunity of starting over to prepare for a graduate degree in engineering. This program would be most suitable for aeronautical or mechanical engineering but a similar program would also apply to the other fields of engineering. The program would consist fundamentally of four basic courses in engineering science each year. Each course would consist of three lectures per week plus an afternoon of laboratory work or problem discussions. A candidate for the Ph.D. degree would, in addition, include about two related graduate courses in a physical science plus a thesis. In addition, the engineering school would offer specialized courses in its extension division as optional courses for those students who desired such specialized training in a particular field.

It is proposed that such a program would consist of:

Two Years—Applied Mathematics
Including vector analysis, Laplace transforms, and other math. methods.

Two Years—Fluid Mechanics
Including hydrodynamics of perfect fluids, the theory of wings and airfoils; viscous fluids; boundary layers, and turbulence; compressible fluids; gas dynamics; stationary and nonstationary flows.

Two Years—Structures and Theory of Elasticity
Including theory of elasticity and plasticity; theories of strength; buckling; shells and plates.

One Year—Dynamics
Including mechanical vibrations of machines; flutter; dynamics of aircraft and missiles.

One Year—Thermodynamics and Heat Transfer

One Year—Survey: Modern Physics for the Engineer
Substantially covering the subject matter of U.C.L.A. course by the same title.

One Year—Applied Electronics

The graduate student working toward a Ph.D. should learn the methods and techniques of engineering research in preparing his thesis under the supervision of an experienced faculty advisor. It is very desirable that the thesis include experience with both the analytical and experimental methods of engineering research. In addition, the graduate students should obtain experience in presenting the results of his research work orally before an audience in a weekly research conference and at least once a year, by presenting a seminar. Such practice in public speaking on engineering topics, if criticized constructively by the audience, is of much more help to an engineer in learning to express his ideas than the formal courses in public speaking.

E. Extension Division and Specialized Courses

Most engineers can not anticipate the exact field of engineering in which they will be active after they leave the university and therefore, it is recommended that highly specialized subjects generally be studied by the engineer after he is engaged in his professional practice. This may be done either with the aid of text books or extension division courses at a neighboring university. Thus, a mechanical engineer who is engaged in the design of gas turbines would do well to supplement his basic engineering science studies with a course in jet propulsion or in turbo-machinery. A course in jet propulsion would include the basic theory of steady and nonsteady flow jet propulsion systems in air as well as in water. A course in turbo-machinery would include a survey of the theoretical methods and the experimental data available for the design of axial flow compressors and

turbines, radial flow compressors and turbines, etc. If he is engaged in the design of combustion chambers for gas turbines, it would be to his advantage to take extension division courses in the theory of flames and combustion including a summary of the aerodynamic as well as the chemical aspects of this problem. If he is engaged in the design of regulators and controls for gas turbines, the mechanical engineer would do well to take extension division courses in servo-mechanisms and automatic control systems. If he has had a good program of courses in the engineering sciences, it is very simple for him to assimilate the subject matter of these specialized courses rapidly and to be in a position where he can make new contributions based upon his knowledge of the fundamentals.

The instructors for these extension division courses should ordinarily be outstanding engineers engaged in the practice of engineering. They will know much more about these advanced fields of engineering than any instructor at the university could be expected to know unless the latter is devoting a considerable portion of his time to research or to professional consultation with an engineering group active in this field. It is generally impossible for any instructor at a university to keep up-to-date in the details of various new fields of engineering development and consequently, the device of utilizing practicing engineers to teach these subjects is almost the only practical method for rapidly introducing these subjects into a university curriculum. The extension division courses taught by professional engineers offer at the same time, an excellent opportunity for the professor teaching a related engineering science to be kept informed of new technical developments and to introduce problems, demonstrations and new developments from these extension division courses into his own courses in the basic engineering sciences and to keep the basic engineering science courses lively and interesting.

F. Improvement in Engineering Instruction

The success of an engineering school in developing outstanding graduates depends primarily upon three factors: (1) Excellent physical facilities including buildings, laboratories, and research equipment; (2) A faculty composed of outstanding engineers with competence in both the teaching and the practice of engineering; (3) A capable group of students selected for their qualifications for engineering. The order of importance is in the reverse order to that listed. These conclusions also apply to graduate education in engineering.

In order to improve the caliber of the graduate students, it is suggested that the most qualified B.S. graduates in engineering be encouraged to continue graduate studies in the engineering sciences. It is suggested that engineers within the upper quarter of their graduating class continue for one or two years of graduate study towards a Master's or Professional Engineering degree; that the top ten per cent be encouraged to continue their studies toward a Ph.D. degree. It is recommended that most of these graduate studies be concentrated on the engineering sciences, and that the student usually defer highly specialized courses until after graduation.

It is recommended that the graduate faculty of engineering be selected from among the top one per cent of engineers in competence and with at least ten years of engineering experience. It is also recommended that the salary for these members of the engineering faculty be comparable with that paid to the top one per cent of the engineering profession. In order to maintain their technical competence, it should be expected that this graduate staff devote about twenty per cent of their time to engineering research or engineering practice.

It is recommended that the instructors in the specialized courses taught in the Extension Division be selected from among the best professional engineers en-

gaged in industry in the particular subject. These instructors in the Extension Division would normally devote about eighty per cent of their time to engineering practice and twenty per cent to teaching. In this manner, the most advanced fields of engineering development would be presented at the university by the real experts without making it necessary for the university to establish large associated development projects in every branch of engineering.

By this dual approach of having the basic engineering faculty devote about twenty per cent of their time to engineering research and development and conversely having outstanding practicing engineers devote about twenty per cent of their time to teaching specialized subjects in engineering, it would be possible to bridge more effectively the gap between engineering school and the engineering profession.

In order similarly to bridge the gap between the engineering school and the university departments in the basic physical sciences, it is recommended that students in the physical sciences be encouraged to take related courses in the engineering sciences and conversely. Each of these departments should, however, respect the different interests of the other and it should be recognized that the courses in engineering science do not displace the related courses in the physical sciences and conversely.

G. Summary and Conclusions

In summary the following recommendations are made to improve graduate education in engineering:

(1) Graduate as well as undergraduate instruction in engineering should be devoted to teaching the engineering sciences, thoroughly and clearly, illustrating the principles by application to modern engineering systems, demonstrating the principles with simple laboratory models, and giving the students practice by realistic design problems.

(2) Highly specialized subjects should preferably be studied by an engineer after he is engaged in this professional practice. He can then concentrate on the courses of direct interest to his field of work. These specialized courses should therefore preferably be offered by the university at its Extension Division in the evening. Mimeographed copies of such lectures should be made available by mail to engineers who cannot attend the university.

(3) Engineering students within the top quarter of their class should be encouraged to undertake graduate study in the engineering sciences. Students within the top ten per cent of their class should be encouraged to continue toward the Ph.D. degree in Engineering Sciences.

(4) The faculty for a graduate school of engineering should be selected from among the top one per cent (in competence) of engineers engaged in each field. They should have at least ten years of experience in engineering practice or research. They should be encouraged to continue to devote at least twenty per cent of their time to engineering practice or research. Their total salary should be comparable with that of the top one per cent of engineers (in salary).

(5) Instructors for specialized courses of the Extension Division should be selected from among the best professional engineers engaged in industry in the particular subject.

(6) Industrial managements as well as the engineers in industry should recognize that in order for an engineer to maintain his technical competence, it will be necessary for him to keep informed of the newest technical developments by such methods as extension division courses or independent study. Such supplementary studies should be encouraged.

Teaching Statistics to Engineers

By WYLLYS G. STANTON, SR.

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The problem connected with teaching statistics to engineering students and to men who were graduated from curricula which did not include statistics courses is already very important and it is constantly growing more so. A recent survey by Dr. Ralph M. Barnes, Chairman, National Curriculum Committee of the American Institute of Industrial Engineers, reported in the November 1953 *Journal of Industrial Engineering*, shows that 18 of 20 schools responding require at least one course in statistics. This is in contrast with the situation in 1946–47 when only eleven schools had such requirements in engineering curricula. Moreover eight of the schools have increased their requirements in statistics and six reported that they would like to make further increases by 1955–56.

What is behind this trend? In part it may be explained by a natural growth in the use of statistical presentations for the selling of engineering projects. One of the finest examples of this is the report prepared by the Ohio Highway Department to show the need for additional road building funds and how they are to be allocated. Another point is that the public is steadily becoming more sophisticated in statistical matters. Witness the alacrity with which critics claimed inadequacy and nonrandomness of the sampling in the second Kinsey report. Engineers have long made use of traffic counts, censuses of populations to be served by various kinds of public utility ventures and expansions, and other statistical procedures, but in the future they are going to need to be better trained, to state confidence limits with respect to their averages and to make other refinements. Refinement in the use of statistics has also been accelerated by the growth of industrial engineering with its emphasis upon statistical quality control, job evaluation, methods analysis and production control. Finally, the experience with controlled materials plans, with the necessity for furnishing all sorts of reports to the government, has greatly increased interest of all engineers in statistical methods.

Important Reasons

Cogent as the foregoing reasons may be there are three other very important reasons for including statistics in the training of every engineering student from this point forward. First is the realization, as instrumentation has improved, that measurements which were once accepted as definite values are only approximations or samples from the whole population of possible readings that might be obtained. Also it is ever more widely recognized that the classical experimental pattern of allowing only one factor to vary at a time completely neglects the important effects of interaction, and that a factorial design is much more fruitful, as well as more economical.

A second point is that engineering work must of necessity include a great deal of computation. Most engineering curricula contain courses designed to teach the use of the slide rule and to convert logarithms from a novelty in algebra courses to a practical working tool, but these courses come early and often there is inadequate stimulus to continue practicing the skills acquired until they become habitual and

automatic. It is true that some courses in mechanics and design aid in further development of computational skills but there is need for more work along this line. Statistics can scarcely be taught without including the working of many problems by the student and they can be designed to yield additional practice in computation as a valuable by-product.

A third and perhaps most important point is that the advances made thus far in the application of statistical methodology to engineering are only a token of those that are yet to come. The only way that they can come about, however, is by having a large body of engineers sufficiently trained in statistics to recognize possibilities and to cooperate intelligently with the professional statisticians who stand ready to help them. In some large laboratories, as at General Electric, statistical departments have been established on the premise that complete mastery of statistics and the development of new techniques, is in itself a life time career. Until the rank and file of engineers are sufficiently well acquainted with the rudiments of statistics to discuss their problems intelligently with these specialists the fullest possible cooperation and progress cannot be attained.

Differences in Statistics for Engineers

The natural question at this point is: what, if any, are the differences between teaching statistics to engineers and teaching it to other students? It is true that in many schools statistics instruction for engineers is handled on a service basis by the mathematics or other departments, often along with students from other colleges. From the point of view of an engineering educator this plan leaves much to be desired.

Engineers are much more sophisticated from a mathematical point of view than many of the students from other colleges. Use of a text which states that it presumes no knowledge beyond elementary or even college algebra, is unappealing to students who have had an introduction to the calculus. On the other hand more advanced texts which state that they are based upon nothing more difficult than elementary differential and integral calculus often make demands that the student is not prepared to cope with. Courses of this type may put engineering students in competition with mathematics majors, some of whom are preparing to be professional statisticians, and discourage them with work in series, matrix algebra, and multi-dimensional space.

Engineering students tend to approach their studies in an air of pragmatism which causes them to respond best to problems dealing with engineering data. We may deplore their lack of interest in studying a subject purely for the sake of intellectual development, and we may endeavor to steer them into more purely intellectual pursuits, but at the same time we do well to sugar coat the pill and to offer courses especially tailored to make the maximum use of their equipment and desires.

Because of the training in drawing and other courses engineering students are conditioned to accept and profit by a maximum of graphical presentation. Much of statistical theory can be treated graphically with profit for students who are properly prepared, and at the same time such presentation would be wasted upon students who do not have well developed traits of structural visualization.

Need Efficient Handling

The majority of all engineering curricula are so firmly packed with courses requiring a lot of work on the part of the student, that there is need for maximum efficiency in handling statistics, or any other course for engineers. The realistic instructor knows that he must compete keenly with other courses to obtain a fair share of the student's time. For this reason a course paced to suit the more leisurely gait of an arts college might be completely out of place for engineers.

In general engineering studies are held together by a strong chain of logic, and the student discovers early that he must

master a field step by step or be forever plagued by the gaps unfilled. In history on the other hand one can learn well the chapter on Henry VIII even though he skipped the one about William the Conqueror. Of course the understanding of the former will be enhanced by a better knowledge of the latter, but the omission it not fatal. For this reason engineering students require a course in which topics are built upon one another with care.

Although as stated earlier, there is increasing realization that physical measurements are far from exact values, this awareness has not fully penetrated many engineering college laboratories. Therefore in teaching statistics to engineers it is necessary to stress the variability of data more than it might be with a class of psychology students who are conditioned to expect wide variations in test scores or other experimental data.

Suggestions for Teaching Statistics to Engineers

Many of the suggestions to follow have already been implied in pointing out the difference between engineers and other students with respect to the study of statistics; still it may be profitable to restate them specifically.

1. Use a step by step development of theory together with the liberal use of demonstrations including actual physical apparatus.

2. Require students to work out enough mathematical proofs to make them appreciate that there is a rigorous basis for everything they are taught to do, but do not pursue this line so far as to take up time that may be better used to introduce other topics.

3. Use problems based upon engineering data. Although measures of central tendency, dispersion, skewness and kurtosis can be learned as well by manipulating a series of psychological scores, the engineer gets more meaning out of the problem if the data is a series of breaking strengths of test pieces.

4. Insist upon neatness and approved form in doing the written work. Encourage the use of tabular arrangements rather than a series of equations. Require proper rounding off of continuing decimals, and establish numbers of significant figures appropriate to the data at hand.

5. Develop problems which contain a minimum number of items adequate to illustrate the principle being studied. In too many texts problems are found which require hours of laborious arithmetic and do not teach any more than a simple problem would. Of course when teaching the method of collecting a series of readings into classes in a frequency array a large number of items is essential. Also it is desirable to have some problems based upon actual data in order that the students do not develop a feeling of unreality, but it is possible to greatly reduce the amount of drudgery often connected with statistics courses without any loss of theory.

6. After eliminating unnecessary work from problem solving, assign frequent problems.

7. Give frequent interim examinations, for experience indicates that they are probably more needed in statistics instruction than in most other subjects. All of the usual reasons apply here; revealing his own weaknesses to the student, indicating to the instructor how well he is getting the ideas to the students, giving the students a sense of accomplishment and encouragement to proceed, etc.

Growing Need for Instructors

There is little doubt that there is an insufficient number of men available to meet the growing need for instructors to teach statistics to engineers. That is to say that there is an insufficient number of men with complete and rigorous training in statistical methods. This is not as bad a situation as it might appear to be at first glance because the greatest need is for instruction in elementary and intermediate statistical methods. If this need can be met the smaller number of teachers needed to handle the few who go on

for advanced training will also be found. In fact it is at the higher levels that it may be expedient to turn the job over to the mathematics or statistics department.

Any good engineering instructor can readily learn enough statistics to handle a class in the elementary phases of the subject. By reading two or three good texts simultaneously he will obtain different viewpoints and a breadth of understanding that would not be possible to a reader working with only one book. By simultaneously is meant to take a particular topic e.g., calculating averages, and find out how it is treated by different authorities. This together with working out many problems will equip one to start the teaching of basic statistics, then classroom contacts will increase one's understanding rapidly.

Educational Research May Aid Engineering Teaching

By J. D. AXTELL, JR.

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One of the dramatic changes which has occurred during the past generation is the emergence of specialization, especially in the professions. This specialization has its roots in the rapidly growing volume and complexity of the information and techniques encompassed by any field of work. The advantages accruing to society from the deepened insights and skills of those who specialize are of course profoundly significant. The difficulties, perhaps not so obvious, are none the less important.

Of the difficulties confronting the professional specialist, one of the most serious is the problem of being aware of, and able to utilize, the results of research and up-to-date thinking in fields other than his own. There are, however, encouraging signs that this difficulty is being recognized, and that something is being done about it. Recently, the use of "interdisciplinary" research teams has led to fruitful results, especially where a problem has complex roots in several areas. For example, a study of the causes of juvenile delinquency in a particular city might involve an interdisciplinary team consisting of a psychiatrist, and economist, a city-planning expert, and a sociologist. Another encouraging sign is the increasing use of modern computing techniques to facilitate the processing of data for research in the social sciences as well as in the physical sciences.

A third area of encouragement involving the exchange of professional information is the growing emphasis on the "teaching" part of "engineering teaching," because this involves a need to know what the research and experience of the professional specialists in education have revealed about the ways in which people most effectively learn. It is the purpose of this article to reach into the great wealth of this information and to attempt to state, as briefly as possible, a few of the findings that may have implications for engineering teaching. The points listed have emerged from the tremendous number of research studies of the various aspects of the learning process, carried on during the last twenty years. In curriculum theory as well as in educational psychology, research is the cornerstone of all the modern work being carried on. Indeed, the healthy skepticism of the physical scientist for unverified ideas has long since been put to use by the educator, and the result has been a rather complete reversal of many of the older theories.

Let us then list, and briefly discuss, a few of the results of the research in education, which have implications for engineering teaching.

1. *The efficiency of learning has been found to be closely related to the meaningfulness of the material presented, in terms of the student's interests and purposes.* The research indicates that the stronger the student's motivation, the more efficient will be the learning process. The important thing to note here, however, is that the determining factor is the student; *his* interests and purposes and motivations are the factors—not the motivations that he should have, or may have

later, or that the faculty suppose him to have, or expect of him. Thus we must deal with the student as he comes to class, in terms of his actual interests and purposes, at that given time. It is obvious that this is extremely difficult, in a situation which involves a whole classroom; yet this is an important principle of learning. One significant corollary of this principle is that it thus becomes important to find out "where the student is now" in terms of both his informational background, and his motivations. Another corollary is that although all members of a given group may have approximately the same informational background, the motivations may be vastly different, and thus the "spread" of learning efficiency may be correspondingly great.

This does not, in any sense, mean that a student's interests and motivations cannot be changed. Indeed, we should expect that they will change, as the student is led by the faculty to see the profession, and his part in it, more and more clearly. Thus, at any given stage in his academic career, the student's "readiness" for effectively learning a given type of material will depend on his present interests and purposes, which will in turn be conditioned by his past learning experiences and by the way he views the future.

2. *The "internal logic" of a subject-matter field has frequently been found to be meaningless if the material is not already within the experience of the student.* To the engineering teacher, with his mastery of the concepts and abstract ideas of his field of specialization, the "internal logic" of a subject may have great appeal. Starting with the introduction of basic concepts and the development of fundamental principles, he can derive the whole superstructure, including the special cases, and the eventual simplified design equations. It all forms a logical pattern, and appeals to his sense of order. In advanced work, there is a very real need for this type of structuring of any field of knowledge. But the plain fact is that when a student is being introduced, for the first time, to a new set of concepts and ideas, his understanding grows best from a series of experiences, the more specific the better. Very often a beautiful logical structure is meaningless to him because he cannot understand "what it is all about." This series of introductory experiences may not lend itself to any logical pattern, yet from the *student's* point of view it yields him a foothold which the "logical order" method may deny him. In the initial formation of sound and correct concepts, it has been found effective to bring the student into contact with the material at several different times, from different viewpoints, and at different levels of difficulty.

3. *Learning has been found to be most effective if generalizations and abstract ideas are based on the student's experiences with specific and concrete materials, and if the student makes his own organization from his own experiences for purposes that are meaningful to him and suited to his own maturity.* This summary statement embodies the two points already mentioned, and adds a third, namely that it is valuable to "set the stage," so that the student can make his own relational structure, at his own level, of the material he is learning. The evidence from the research indicates that it is the process of going from the understood to the new, from the specific to the general, and from the concrete to the abstract, which allows the student constantly to reorganize his thinking at succeedingly advanced levels of sophistication. In this way, difficult abstract concepts are soundly built up, and eventually the student is ready to attempt an organization of the whole field, and to appreciate its internal logic, because now its components and relationships have meaning for him.

4. *Learning is an actual activity.* For a long time, learning was thought of as a kind of absorbtion process. Gradually, as ways of teaching other than the lecture method were tried, and as the body of research information in both psychology and education grew, it became apparent that the word "activity" conveys a much

truer picture of what the learning process actually is. In the light of the research, learning is now conceived as modification of behavior, whether this behavior is a method of skiing, or a method of attacking a problem, or an active set of attitudes. In order for this modification of behavior to occur, the learner must interact with his environment, whether this environment be a complex of ideas or a playing field. In other words, the learner is active. Educational activities which require the learner to participate actively are therefore valuable, and this is the basis, in educational theory, of the so-called "project method." Engineering education, with its laboratories, field trips, research studies, and construction projects, is particularly well equipped with opportunities for active student participation. Seminars, group investigations, and individual study are also valuable ways to encourage "active" learning. Even the lecture method, inherently fraught with the ever-present possibility of an entirely passive audience simply copying the blackboard, can, if properly handled, trigger a tremendous amount of aggressive mental action in the classroom.

5. *Learning has been found to be more effective if students feel they have a share in planning the goals and the process.* Quite apart from the impressive amount of evidence on this point, there are other interesting aspects to consider. The value of activity in learning has been mentioned earlier. Here the opportunity is to utilize activity, not only to enhance learning of subject matter, but also to focus student attention on goals and on the learning process itself! Also, from the standpoint of the evidence about the need to "start where students are," allowing students to share in the planning of a course can be a highly useful method of assessing present status. Still further, we may note the value of developing, in the students, the feeling that material and method is, at least partially, their own responsibility, and geared to their own goals and backgrounds.

6. *Attitudes and emotions brought by a student to a learning situation have been found to affect greatly the student's ability to learn.* In several ways, engineering is in a particularly favorable position in this regard, since most of the students studying in this field are doing so because they want to. The glamor and obvious immediate applicability of the physical sciences in general, and of engineering in particular, predispose the student in a way very conducive to maximum learning. Also, there is very little chance for previously acquired emotional bias to affect learning, as is frequently a problem in areas such as philosophy, sociology, or aesthetics. Engineering courses are generally not required if the student is specializing in another field, whereas the reverse is not as true. This means that with a few exceptions, engineering courses are not attended with the attitude implied by the expression, "I have to get this over with." In some engineering courses, however, this is the very attitude found, particularly where the material is of a non-technical nature, as in courses in report writing, public speaking, and other aspects of professional life. Recognizing the value of a positive, constructive attitude in facilitating learning, many instructors in such courses spend a reasonably large block of time at the beginning of the term, developing in the students' minds this mental readiness, of which we spoke earlier. This can be done by showing, in various ways, that the material does have a practical value to the student. Obviously, too, the attitude of a student toward his instructor is a powerful force in a learning situation.

7. *Learning does not take place in isolation.* Contrary to many earlier ideas, the evidence from the research has now shown that learning is affected simultaneously by the whole complex of forces and situations, within and surrounding a human being, no matter where he is, He interacts with his environment, and thus learns, as a whole person, not simply as an "intellect." Attitudes, desires, and capacities are factors that are all molded

by, and themselves mold, the opportunities, pressures, and the people involved in the total learning situation. Thus, many complex adjustments take place at once, and the "total effective curriculum" is a sort of vector sum of all the experiences with which a student comes in contact. The individual and his personality may be thought of as forces in a larger field of force, which is his total environment. Any change anywhere will cause a readjustment of the whole field. Indeed, this is the so-called "field theory" of learning, which is gaining ever wider acceptance among educators as a clear picture of the learning process. In this light, consider such things as the student's attitude toward his future, a feeling of pressure from a high work load, or regular contact with an inspiring faculty member. If we are to be realistic about the effectiveness of our educational process, we cannot afford to treat these matters lightly.

An Engineering Curriculum Designed for Today's Student

By B. LEIGHTON WELLMAN

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The engineering curricula of today—and yesterday—are "on the block." They are being assailed from many directions by innumerable engineers and educators who believe that the conventional and time-honored program of engineering education is becoming increasingly inadequate for modern needs. The report of Dean S. C. Hollister and his committee on "Adequacy and Standards of Engineering Education"[1] has fanned the smouldering fire of dissatisfaction, and it is probable that many faculty committees have been impelled to reexamine their own programs. But while committees are meeting and debating, papers are being written, conferences are being held, and the air around every small gathering of professors is blue with smoke and argument. In all this talk one common fact is evident: there are as many opinions as there are individuals who hold them. Thus it is with some temerity that this writer proposes to discuss his own personal opinions, and to advance a few bold suggestions for the improvement of present day engineering curricula.

Considered from a purely pragmatic viewpoint, an engineering curriculum should be a carefully designed educational process whereby certain specially selected but undeveloped raw materials are processed and converted into an end product having known and desirable characteristics. It is also axiomatic that any continuously successful process must be adjustable to variations in the incoming raw materials, and it must also be improved and modified according to the need and demand for the outgoing product. It is entirely logical, therefore, that the specific and detailed design of a curriculum should be based upon an accurate and realistic evaluation of the high school graduate of today and the engineering graduate of tomorrow.

Different Background

The high school graduate of today is very different from his predecessors. His education has been designed for living, and the question of whether or not this has resulted in better citizens need not be debated here. For the student who wants to become an engineer, the change has been detrimental. Since the number of hours spent in the classroom and on homework has remained the same or been diminished, the addition of more interesting subject matter has obviously reduced the time devoted to the three R's. Basic concepts are still being taught, of course, but the long hours of drill that make for mastery are no longer available. Unfortunately the effect is most pronounced in simple arithmetic and algebra. Witness the college freshman who can solve a quadratic equation (with the proper formula), but fumbles pitifully when asked to mentally multiply $\frac{7}{8}$ times $\frac{2}{3}$. To stem this tide in the elementary schools is probably hopeless; in the secondary schools the intervention and cooperation of college educators may bring about

[1] "Report of Committee on Adequacy and Standards of Engineering Education," *Journal of Engineering Education*, January, 1952.

some improvement; but the engineering colleges must realistically recognize today's level of achievement in mathematics, and design their curricula accordingly.

The home life and social environment of today's high school student has also changed rapidly and radically from that enjoyed by Dad. Sports demand more and more time: they must be practiced for hours, participated in, cheered from the bleachers, and now watched on television. Clubs and organizations spring into being on the slightest stimulus to be nurtured by more hours of attention. For the student who would like to study, the number and variety of available distractions is almost overwhelming. All of these things consume the waking hours, and regardless of how we may value them, they do precondition the college freshman.

Time Element

For most of the above activities the average high school student has adequate time because he is carrying a schedule of only four, or at the most five, subjects' and his homework requires only an hour or two per day. But even the hardiest and most determined young man is stunned by the initial impact of his college engineering program. This new schedule upon which he has suddenly embarked will have five, six or even seven major and difficult courses. To this may be added orientation lectures, compulsory physical education, and probably several hours per week of military training. The number of intensive classroom and laboratory hours will total at least 30, and may be as high as 35. Certainly his days are full and there is little time for dawdling, but his evenings and weekends are also carefully planned. He quickly learns to expect 4 to 6 hours of preparation each day, and the weekends become only a means of completing assignments that couldn't possibly be done during the week.

That the above description of a typical engineering program is not exaggerated can be verified by examining the catalogs of the various colleges of engineering. Credit hours per semester will range from 17 to 19, with the majority inclining toward the higher figure. Since it is a common practice to consider three hours of work—classroom, laboratory and preparation—the equivalent of one credit hour, it is apparent that the work week will range from 51 to 57 hours. And this is for the average student and assignments that are not unduly ambitious! Of course it must be admitted that this heavy program has been completed successfully by thousands of young men, but the fact remains that today the transition from high school to college is abrupt and difficult for many students.

The general knowledge possessed by today's high school student concerning the world around him is amazingly extensive and diverse. By close association he has somehow acquired a smattering of knowledge about radio and television, about bicycles and automobiles, about airplanes and jet engines. But in spite of this interest in engineered products his acquaintance with simple hand tools and elementary manufacturing processes is extremely limited. Small apartments, basementless houses, and increasing urbanization are producing a new generation of manually inept and mechanically ignorant freshmen. And a surprisingly large number of these unskilled and inexperienced young men enter our engineering colleges, bringing with them only a desire and a probable aptitude for the career they have chosen. Certainly an engineering curriculum ought to be designed to correct in some measure this modern deficiency.

They Want To Be Engineers

But the great majority of students who enter engineering do have one thing in common: they want to be engineers, and they are normally enthusiastic about the prospect; they excitedly anticipate a prompt introduction into the intricacies of whirring gears, ingenious machines, river spanning bridges, towering structures, complex chemical plants, and all

of the many magical accomplishments of engineers. The bright-eyed eagerness of September warms and stimulates the vacation-refreshed professors. Months pass, interest wanes, and in the cold gray light of December it is sadly evident that there will be no engineering this year. English, History, Language, Chemistry, Physics, Mathematics, Drawing—this is the diet, almost entirely devoid of flavor or seasoning, that must be gulped down during the first year. There may be a soporific hour per week of well diluted engineering orientation, and the drawing course may touch upon a few glimmering mechanical terms, but in general the meat course will not be served until later. Motivation is much discussed, but most engineering colleges have yet to recognize its psychological importance by peppering the dish to make it tasty.

We might summarize, at least in part, the properties and characteristics of our raw material as: 1) a weakness in arithmetical skill, 2) inexperience in concentrated study, 3) a lively interest in non-academic fields, 4) a lack of simple practical experience, and 5) a strong initial desire to participate in engineering experiences. These are generalizations, of course, but they are sufficiently characteristic to warrant sober consideration, not only in the design of the curricula, but also in the planning of extra-curricular activities and student counseling.

End Product

Turning now to the end product—the result of four years of intensive instruction and stern tutelage—let us consider what its properties are, or ought to be. The engineering graduate will, of course, almost inevitably, have acquired a fund of facts—more or less related and of some utility. But his real strength will lie in his sound knowledge of basic principles, and his keen appreciation of their possible applications. His knowledge of actual engineering practice will be meager, but his future employer has special methods and techniques, and will therefore expect, and frequently insist, that he alone can give proper instruction here. Hence his employer will naturally expect a thorough knowledge of fundamental principles and little of special topics. This situation is commonly acknowledged, and lip service given thereto, yet at the same time more and more advanced and specialized subjects are piled on top of the inverted educational pyramid. Since the time dimensions of the pyramid are limited, even strained, the downward pressure of the advanced material is squeezing out the introductory subjects. Thus the elementary and fundamental topics are being shortened, abridged, and even eliminated. Such a course of action must eventually weaken the product. Advanced topics must, of course, be available to those who want and can use them, but not at the expense of basic kowledge.

It has been rather aptly said that the engineer is a man who deals with the four M's—men, money, materials and machines. Of materials and machines our engineering graduate has learned a great deal. Of men and money he is apt to be colossally ignorant at the time of graduation. It is his salvation that in the years ahead he will rub shoulders and temper with many men, and thereby learn in the hard school of experience how to live and work with them. But this live and learn process could be greatly expedited by a few brief studies in psychology, management, and labor relations.

Of money little or nothing is said during the usual engineering course. The physical attributes of materials and machines are meticulously studied, but rarely are the actual and relative costs mentioned. Labor, materials, and engineering are key elements in the cost of a product, and their comparative importance is frequently ignored or dismissed as of little interest. Yet students are usually keenly and realistically interested in the cost of a milling machine, a die, or a ball bearing. Cost accounting, purchasing, marketing, and allied subjects might very well deserve a small place in the modern engineering curriculum.

Outside of his workaday world the en-

gineering graduate should be prepared to assume a responsible place in the social, cultural, and political work of his community. That he has not done so in the past has been attributed to his narrow and highly specialized education. To correct this deficiency many engineering colleges have in recent years added a "band of cultural subjects" to their already overcrowded curricula, but not of course without some reduction in technical subject matter. The width of the "band" varies, but the arbitrary figure of 20 per cent that has been advocated by proponents has been adopted by a number of colleges; other schools have found it necessary or desirable to limit this aspect of their culture to a lesser amount. No attempt will be made here to list the many courses that are customarily included in this category, nor to debate their place in that list.

Unresolved Points

Sincere and well intended as these efforts toward cultural improvement may be, several points remain unresolved in the opinion of this writer. Has the introduction of these courses actually accomplished the desired end? Or is the engineer by nature and inclination exclusively interested only in his own field, and therefore immune to the innoculation? Unfortunately, statistical evidence is lacking. How can we accurately establish the necessary allocation of time to this study, and at what point will the soundness of the technical instruction be imperiled? Here again the writer knows of no unbiased factual information on this subject, and it may be that such data can never be accurately formulated. Perhaps the intangible values ascribed to these courses must continue to be accepted on faith, but the pressure for more and better technical instruction within the confines of four years' time demands a more critical attitude. The general cultural course that crowds or displaces a technical subject should certainly be one of unquestionable value to today's graduate engineer. Any other—however venerable and hoary—should be suspect.

It should be understood that the writer is by no means antagonistic to the inclusion of nonengineering subjects in the engineering curriculum, but rather feels that these courses should be selected with the greatest care. They will necessarily be introductory in nature and designed primarily to implant the seed of intellectual curiosity. Though most of the seed will fall on barren soil, some will germinate and flourish for many years under the cultivation of a natural interest. Immature freshmen having a pronounced scientific bent are notably unreceptive to such subjects, but mature juniors and seniors are inclined to be more appreciative of their potential value, hence it would be desirable to put the nontechnical courses into these later years.

Desirable Characteristics

In summary, our end product should possess the following desirable characteristics: 1) a sound fundamental knowledge of engineering facts and principles, 2) a limited introductory knowledge of advanced topics, 3) some knowledge of human relations, 4) an appreciation of monetary values in engineering, 5) a breadth of interest that will enable him to fit usefully and harmoniously into the life of his community. Achievement of these objectives should be the goal of our engineering colleges.

If it is agreed that the foregoing objectives are desirable, and if it is conceded that today's high school graduate has been described with reasonable accuracy, then these initial and final conditions ought to serve as a guide in the design of an engineering curriculum. And the term "design" is used here with all the implications of original creative effort. Many curricula are revised, but few have been designed. Revising a curriculum is customarily and traditionally a process of shifting small discrete packets of knowledge, known as courses, from one hour, semester, year, department, or pigeonhole, to another. The size of the

packets may be altered, but the contents are rigidly prescribed and rarely allowed to mix with, or be contaminated by, the contents of closely related packets. Of course the dimensions of the packets are dictated by the clock, but if all the contents were dumped into a common vessel, stirred with an enlightened spoon, and mixed with understanding and tolerance, it is entirely possible that the mixture could be strained, sorted, and recombined into new packets. And it is conceivable that these new units might form a better and more logical sequence of instruction than did the original assortment. Certainly much of the repetitious, overlapping, and extraneous material could be eliminated, but this integration and streamlining could be achieved only by an almost complete disregard for traditional departmental domains. And these ivy-clad walls would be the greatest obstacle of all.

Logical Parts

If we boldly proceed, however, to spread before us the total contents of all the packets of knowledge, it would soon be apparent that the whole can be divided into three logical parts:

1) The languages of engineering, of which there are three: mathematical, graphical, and verbal. These three modes of expression are employed continually by the engineer, and he must become fluent in their use at an early stage of his studies. They might also be called the "tool courses" of engineering.

2) The general field of engineering, in which there are three broad divisions: materials and processes, energy, and personnel. Knowledge and understanding in these three fields must logically be followed by use and application in order that the separate principles of each may be integrated and directed into two channels: design or synthesis, and testing or analysis.

3) The studies in living, of which there are many. These are the studies that lead toward a broader viewpoint and a more tolerant understanding of the non-engineering world in which the engineer must live. They are—to some degree—essential to his social and personal development.

Within each of the above broad classifications of knowledge, logical sequence and desired achievement should be of paramount importance. The stream of

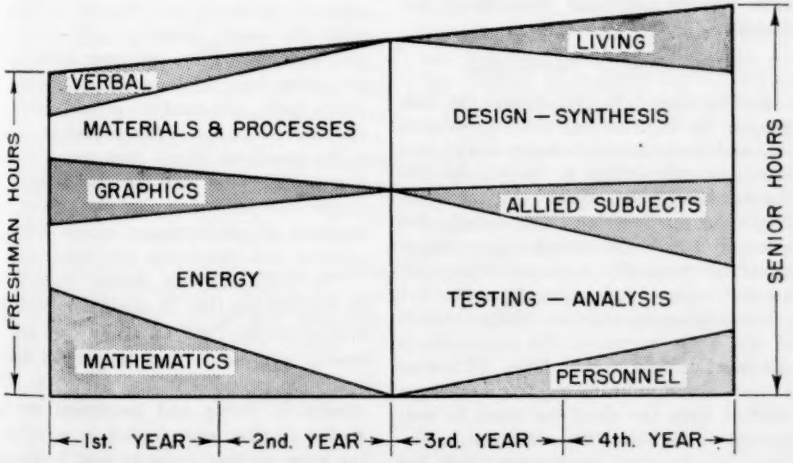

FIG. 1. The tapered engineering curriculum in conventionalized form.

learning should flow smoothly and continuously forward even though the pace must be adjusted to that of parallel and concurrent studies. For administrative and calendar reasons the flow will be regularly interrupted, but the division of knowledge into individual courses should not be unduly influenced or prejudiced by presently existing courses, staff idiosyncracies, or departmental organizations. Neither should the divisions of knowledge be so small as to scatter attention or break the unity of learning. Five subjects at any one time would be a desirable maximum.

Without attempting to further subdivide the above fields of learning, let us fit these major units into the standard four-year program. The chart shown in Fig. 1 is a conventionalized representation of the proposed course of study. The height of the chart is proportional (ideally) to credit hours per semester (or hours of study per week). It tapers from a relatively light program at the beginning of the freshman year to a somewhat heavier schedule during the senior year. This feature is obviously designed to ease the transition from high school to college. The heavier schedules of the junior and senior years can easily be carried by these mature and more experienced students.

Languages of Engineering

During the first two years the languages of engineering—verbal, graphical, and mathematical—begin heavy and taper to completion as shown by the shaded triangular areas. At the same time the engineering courses—divided into only two broad classifications—begin light and gradually increase in time allotment. These five areas represent five course sequences, and the relative heights of the areas represent the approximate allotment of time to each field. (Physical education and military training have been omitted from the chart but must be considered in the total time allotment.) Because of its vital importance, and for reasons previously discussed, mathematics has been given the largest initial share of time. Graphics is second because the entering freshman has had little or no previous instruction in this field. Verbal is third because it has received considerable attention in high school.

Materials and processes should begin in the shop with the forming and fabrication of common materials. This is not only a simple and elementary starting point, but it is also an opportunity to acquaint the novice with the basic tools of engineering and to fill certain voids in his vocabulary. The chemistry and metallurgy of materials would follow.

Energy in its various forms—mechanical, thermal, electrical, atomic—should also be studied in orderly sequence, and that order would not necessarily be that of classical physics, nor would all topics necessarily be taught by physicists. Theory and engineering applications would be taught in unison in engineering laboratories with engineering equipment by engineers.

During the last two years the engineering courses gradually lighten to allow increased time for allied subjects, living, and personnel courses. At the beginning of this last two-year period the student will have acquired a sufficient basic knowledge of materials and energy to embark upon the more creative work of design and analysis. Here he must draw upon his entire fund of knowledge, employ all of his tools, and combine ideas from various sources to solve his problems. This is the synthesis of all that has gone before. Here too will be the testing of larger and more complex equipment, the analysis of performance where different sciences and principles are involved.

The allied subjects include those fields of engineering that lie slightly outside the chosen major field of study but are so closely akin to it that they must necessarily be included in the program. The studies in living and personnel are included in this later period in order that the more mature students may better appreciate their values.

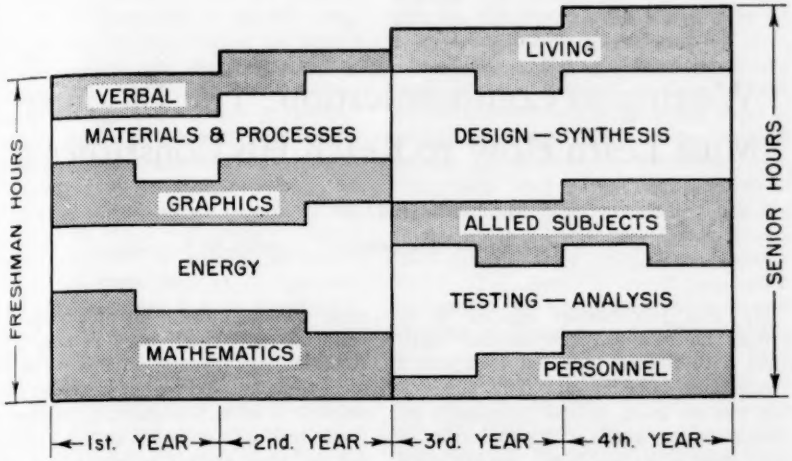

FIG. 2. The tapered curriculum as it might appear in standard credit hour form.

Fig. 2 shows the general pattern of Fig. 1 as it might appear after being adapted to standard credit hour form. Here the ideal triangles and trapezoids have been changed to the rectangular blocks necessitated by traditional educational procedure, but the general trends of Fig. 1 are still apparent. It should be understood, of course, that the particular pattern shown in Fig. 2 is purely illustrative of a broad concept: no special significance should be attached to the relative heights of the blocks. The fact that consecutive blocks do not increase or diminish in perfect order is an intentional distortion introduced here to show the inevitable effect of practical pedagogy.

Broad Pattern

Here then, in broad sweeping strokes, is a pattern for future engineering curricula. Its merits are probably debatable, and its method controversial, but it is to the best of the writer's knowledge original. To adapt it to an existing engineering college would be a laborious undertaking, and one fraught with many dangers and dislocations. It is probable that present tool courses could easily be adapted to this new pattern; the studies for living could be culled from a very wide field of learning without serious dissension; courses in personnel are young and flexible, hence very adaptable. But the division of engineering courses into two broad streams of logically integrated learning could only be achieved by a complete reexamination and reevaluation of the sum total of undergraduate engineering studies. The task is by no means impossible, but it would require the coordinated efforts of a group of learned and determined scholars. And the fruit of their labors might be sweet and nourishing to future generations of engineers.

Writing as Communication: The Engineer Must Learn How to Reach His Constituents

By JOHN I. MATTILL

Director of Publications, Massachusetts Institute of Technology

My own professional interest is in writing on technical subjects for audiences with limited technical background —sometimes none at all. This suggests that you are going to hear principally an account of the wonders of popularization —the work of Rudolf Flesh, and the other ways of making unpalatable material more useful to semi-technical and popular audiences. Before I reach this stage, however, there is a more fundamental subject of journalism to be considered; for I am deeply concerned with the broad relations of science and engineering to popular writing.

Journalism about scientific events has traditionally dealt with *facts*. Atomic fission has been described in popular language so many times since 1945 that it must now be as near to "common knowledge" as any scientific subject of moderate complexity. The electrons crossing between cathode and plate of a vacuum tube have been exposed to countless comparisons with more graphic phenomena. Members of the National Association of Science Writers have been writing good accounts of the accomplishments of science and engineering—such as these—for many years.

Yet those of us in public relations for science or technology discover, nearly every day, that something is missing. We have communicated *facts*—but we may have failed to communicate *meaning*. We have reached the ultimate point where we have to say, "I'm sorry but that comes out of the theory of relativity, and it's very difficult, if not impossible, to explain without quite a bit of physics and mathematics. You'll have to take it on faith." [1] But through all this we do not seem to have conveyed an understandable concept of what a scientist or engineer is really trying to do, what he can and cannot do, what are his purposes, how does he go about his stated work, . . . indeed, what science and engineering really mean.

You will all remember how the spring's concentration of tornadoes inspired calls for Congressional investigations of the Atomic Energy Commission—in the face of the most serious and careful deliberations and denials from all manner of scientists. I am worried that the demands were made; and I am worried that they could be taken so seriously, on so many sides, for this reflects a basic misconception of what scientists can learn with what degree of certainty. It is a demonstration of the common difficulties in understanding what the scientist and engineer is about.

Major Misconception

The tendency in journalism seems to be to set scientists apart as experts—like statues towering above and uncomprehending of other mortals. But this is a major misconception: a scientist is not, after all, any more elevated than his fellow men. Are not scientists and engineers very much like the rest of us, so far as their approach to their problems is concerned? "The stumbling way in which even the best of the scientists in every generation have had to fight through thickets of erroneous observations, misleading gen-

eralizations, inadequate formulations, and unconscious prejudice is largely neglected by those expounders of the alleged scientific method who are fascinated by the logical rather than the psychological aspects of experimental investigations," says Dr. James B. Conant in his useful volume on "Science and Common Sense." [2]

It is hard, too, for those steeped in the tradition of scientists as experts to understand that these men admit and comfortably live with an inability to resolve some of the basic facts of the physical world . . . the wave vs. the corpuscular theories of light, for instance. The scientist's answer to a question on this matter is simply that the question has no meaning: "We physicists have stopped asking it; but if you insist, we may say that a beam of light is at one and the same time a set of particles and waves. If the solidity of matter seems to have gone out from under you, don't for a moment think that this has impeded the advance of science, for quite the contrary is the case," as Dr. Conant expressed it in recent lectures at Columbia University.[3]

The dependence of scientists and engineers on communication among themselves is another of the factors not commonly understood by nonscientists. But it must be a basic consideration in national policy bearing on the classification of scientific work and the international exchange of information and of scientists themselves. Only when you understand what science is and how it operates can you see what is meant by the familiar comment that no scientific fact can long remain a secret from another scientist. Only when you know something about what Dr. Conant has chosen to call "the tactics and strategy of science" can you see why the so-called McCarran Act is subject to such widespread criticism from scientific and professional people.

These are some of the things about science which need to be better known throughout this country, by people in non-scientific activities and especially by people who administer work which depends on scientists or engineers. This includes the vast majority of our voting citizens, the "new lay administrators of science," they have been called.

As I see it, this problem relates very especially to teaching engineering and science students how to write and to be in general articulate. These are things about science and engineering which your students may need to put across to their supervisors in years to come. They are things which all scientists and engineers must carry to their "constituents" everywhere. This seems to me of paramount importance to students of science and engineering because they will be in the small minority of our citizens who have behind them the experience of work in science or engineering. Laymen, Dr. Conant says, fail to understand "the tactics and strategy of science" because of a fundamental ignorance of what science can or cannot accomplish; only those who have personal experience in the profession seem able to overcome this hazard; theirs is a special point of view which comes only from work in science or engineering.

Communicating Ideas

If the future of science depends on how widely scientific activity is understood—and this may indeed be the case—then the future of science may well depend on how literate is our coming generation of scientists and engineers—on how well they can tell this story to those whom they meet. Telling it is not an easy task at best, and my frequent references to Dr. Conant's writings are intended to be most complimentary. He has written and talked about these things in an extraordinarily effective way—in lectures at Yale University, published as "On Understanding Science" [4] later expanded to "Science and Common Sense," and at Columbia University, published as "Modern Science and Modern Man."

Already my approach to this matter of writing has been that of a journalist: I am concerned more about communication than grammar; I put the utilitarian aspects of our language ahead of the

academic. This is to say, I do not consider writing to be principally a problem of grammar and syntax, vocabulary as such, and precise expression. I try not to spend most of my effort on the frills and decorations: a split infinitive holds no terrors, and punctuation can be put in or left out on the basis of its need for adequate comprehension. I consider writing as a problem of effectively communicating ideas.

This approach begins with an analysis of the audience for which the writing is intended—its requirements as to subject matter, interpretation, and readability. Words must be tailored to the audience which will read them—be that audience the technical director, the project financial officer, the company executive, the industrial specialist, the scientist in an unrelated area of interest, the nonscientist with a clear interest in the subject, or the nonscientist who has no apparent reason to care.

Tailoring writing to its audience is not so easy as it may sound. The audience, in general, knows less about the subject than you or I anticipate—and, almost without exception, needs more interpretive information than most of us would normally choose to provide. This business of tailoring writing to its audience is the principal point of the applied psychology developed by Dr. Rudolf Flesch of Columbia University. His books—"The Art of Plain Talk" or the later "The Art of Readable Writing" [4a]—are the best demonstrations I know of the practical value of what he has to say. These books are often used as textbooks of writing; they need to be supplemented principally by some good thinking on the nature and methods of interpretation in writing.

Journalists' Approach

The journalists' approach to learning how to write is to *write*—just as some learn to swim by being tossed off a pier into deep water. The analogy can perhaps be carried further: after that first start, swimming strength is built up by watching and copying others and by swimming more and more in the process . . . not by listening to and practicing stylized techniques. The result may not be suitable for the Olympics—few journalists claim that their works are literary masterpieces—but it surely prevents drownings.

When this approach is applied to teaching writing, you are sure to end up with someone who can write *something*—who is not completely tied in knots by the appearance before him of an assignment and a typewriter.

What he is asked to write about is also important. Journalism by definition is writing about real events; journalism schools keep away from assignments which involve their students in theoretical or imagined situations.

In the engineering environment, some writing can clearly be a part of the requirements of other courses, taking the form of laboratory reports and assigned papers. But most of it should be for even larger ends—for actual publication and so for actual service in the business of communicating ideas. This can mean publication in the college newspaper, or in the school's magazine. But, most important I think, it can mean contributing to technical and professional journals of national scope.

There are several hundred such journals.[5] Many of their editors are anxious to have good technical reporting about the research activities in colleges and universities—and, to a lesser extent, about the educational developments as well.

Let engineering English students turn themselves into reporters; with your help as editor, they can be sure of turning out something—and before long, too—which can end up in print with a by-line and often a small check to make the ultimate reward a financial as well as a professional one.

My enthusiasm for this proposal is based on personal experience. I can testify to the inspiration which comes to

a student who deals directly with the editor of a publication which he sees and respects—who perhaps becomes that editor's unofficial correspondent for the college in which he studies. This motivation is worth a great deal. It combines the experience and training in writing with the professional advancement and orientation which comes to an author. I think it can help us turn out literate engineers who find writing a pleasant and perhaps even easy experience.

REFERENCES

1. James B. Conant, "Modern Science and Modern Man," Columbia University Press, 1952, p. 37.
2. Conant, "Science and Common Sense," Yale University Press, 1951, p. 49.
3. Conant, "Modern Science and Modern Man," p. 47.
4. Conant, "On Understanding Science," Yale University Press, 1947.

4a. Harper and Brothers, 1946 and 1949, respectively.

5. See "Directory of Newspapers and Periodicals," N. W. Ayer & Son, Inc.

College Notes

The **University of Michigan**, College of Engineering, has announced two Intensive Courses in Automatic Control. The first is scheduled for June 14 to 19 inclusive, and the second for June 21 to 23, 1954, inclusive. The courses are built around the principles and application of measurement, communication and control. Course I will consist of the fundamentals in each of these fields and will include some fundamental work in nonlinear systems. Course II will take up applications of the fundamentals to more advanced problems.

April 15 is the closing date for registration. Further information may be obtained by writing to Professor M. H. Nichols, room 1523, East Engineering Building, University of Michigan, Ann Arbor, Michigan.

ASEE Summer Institutes—1954

Science and technology are moving rapidly ahead in broad areas which hold significant promise for the future of engineering. In order to assure maximum progress in engineering education and to expedite the translation of new fundamental concepts into engineering practice, the American Society for Engineering Education is inaugurating this year a series of conferences to be known as Summer Institutes. This program will help to implement the recommendation of the ASEE Committee on Engineering Education that modern physics, including nuclear science and solid state physics, should become an essential study in engineering education.

Each Summer Institute will deal with a specific subject matter area. The purpose of the Summer Institute is to seek out and clarify fundamental concepts, to assess the material as to its importance in engineering education, and to arrive at a logical orderly pattern for teaching purposes. By this positive approach, it is hoped to bring engineering education into closer proximity to the significant new developments which will affect its future. In these conferences, the divergent viewpoints of the research engineer, the scientist, and the educator will be brought to bear upon the problems.

Two Summer Institutes are planned for 1954—one in Sold State Physics in Engineering Education and the other in Nuclear Physics in Engineering Education. Both conferences will be financed by grants from the National Science Foundation. Each Summer Institute will consist of a working conference of 20 to 30 leading authorities in the particular field who will make a comprehensive analysis of the material and lay the groundwork for the open conference. The open conference will feature about 6 to 8 of the participants of the working conference, discussing important fundamental concepts and organization of the subject matter as it relates to engineering and engineering education. There will be ample opportunity for open discussion by those in attendance.

These conferences are supported in part by grants from the National Science Foundation. The American Institute of Physics is cooperating in the Nuclear Science Foundation.

Solid State Physics in Engineering Education

University of Illinois—March 8–10, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Carnegie Institute of Technology—June 21–25, 1954

Open to engineering and physics teachers. Attendance will be limited to 150. For information and registration forms write to Professor John W. Graham, Carnegie Institute of Technology, Pittsburgh, Pa.

Nuclear Science in Engineering Education

Columbia University—April 22–24, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Northwestern University—September 7–11, 1954

Open to ASEE members. Attendance will be limited to 100. For information and registration forms write to Professor Robert L. Young, Technological Institute, Northwestern University, Evanston, Ill.

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ASEE Summer Schools—1954

The following Summer Schools, sponsored by ASEE Divisions, are open to ASEE members. For information and procedures as to registration, please write to the person indicated in connection with the particular Summer School. All of the Summer Schools at the University of Illinois either precede or follow the Annual Meeting so that those in attendance can combine Summer School attendance with attendance at the Annual Meeting. The program for the Annual Meeting of the ASEE will be mailed to Society members during the last week of April.

Economics of Engineering Summer School sponsored by the Engineering Economy Commitee.

Theme: "An Evaluation of Analytical Techniques of Engineering Economy."
Time: June 12–13, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Arthur Lesser, Jr., Head, Industrial Engineering Dept., Stevens Institute of Technology, Hoboken, N. J.

Electrical Engineering Summer School sponsored by the Electrical Engineering Division.

Theme: "The Elements of Design of Digital Control Circuits."
Time: June 18–20, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Dr. L. V. Bewley, Dean of Engineering, Lehigh University, Bethlehem, Pa.

Summer School in Advanced Engineering, with Emphasis upon Development of Creative Thinking jointly sponsored by Educational Methods Division and General Electric Co. Attendance by invitation only.

Time: Aug. 30–Sept. 4, 1954. *Place:* Schenectady, N. Y.
Information: R. H. Buescher, Technical Education, General Electric Co., Schenectady, N. Y.

Workshop for Humanistic-Social Project sponsored by Humanistic-Social Division.

Time: June, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Sterling Olmsted, English Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

Engineering Mechanics Summer School sponsored by the Engineering Mechanics Division.

Theme: "Evaluation of the Engineering Significance of Graduate Training in Mechanics."
Time: June 11–12, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Dan Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

Summer School sponsored by the Mechanical Engineering Division.

Theme: "Teaching of Machine Design and Manufacturing Processes."
Time: June 18–25, 1954. *Place:* University of Illinois, Chicago, Ill.
Information: Professor K. E. Lofgren, Machine Design, Cooper Union, New York, N. Y.

Do You Know—

(*Continued from page 420*)

► For the Instrumentationalists, there will be a one-day conference on instrumentation on Saturday preceding the Annual Meeting at Urbana. Professor Bob Jeffries at Michigan State will gladly supply information.

► As the time draws nearer for the Annual Meeting and our Secretarial desks sag under the ever rising avalanche of mail in preparation for the Meeting, we can't help but feel grateful for the competent crew at the University of Illinois which has been working diligently all year planning the multitudinous details for the Meeting. They're doing a grand job and we want you to know it. Lisle Rose, our genial Chairman of the Local Committee, is now hale and hearty after his bout with the Surgeon (he lost) and is moving along at his usual jet propulsion pace.

See you at Urbana.

Best regards,
ARTHUR BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
*Upper New York	Cornell University	October, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

* No Date Set.

New Members

ANDERSON, WALLACE, Professor and Head of Physics Department, The Citadel, Charleston, S. C. C. T. Razer, John Anderson.

ANTOINE, TAMLIN C., Associate Professor of Technology, Hampton Institute, Hampton, Va. H. S. Shivar, L. K. Downing.

APPEL, DAVID, Instructor in Mechanics and Hydraulics, State University of Iowa, Iowa City, Iowa. C. J. Posey, F. M. Dawson.

AULD, ROBERT B., Industrial Coordinator, Assistant Professor of English, Fenn College, Cleveland, Ohio. M. B. Robinson.

AUSTIN, WILLIAM W., Associate Professor of Mechanical Engineering, N. C. State College, Raleigh, N. C. J. K. Whitfield, J. S. Doolittle.

BARCLAY, LELAND, Associate Professor of Civil Engineering, University of Texas, Austin, Texas. J. S. Doughtie, J. A. Focht.

BARKER, RICHARD C., Instructor in Electrical Engineering, Yale University, New Haven, Conn. A. G. Conrad, H. J. Reich.

BAUGH, ROBERT L., Assistant Professor of Electrical Engineering, Colorado School of Mines, Golden, Colo. H. E. Fletcher, A. L. Gosman.

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MCDONOUGH, DONALD L., Assistant Head of the Department of Mathematics, Drexel Institute of Technology, Philadelphia, Pa. K. W. Riddle, W. J. Stevens.

MORRIS, WILLIAM T., Instructor in Industrial Engineering, Ohio State University, Columbus, Ohio. Eugene Richman, W. G. Holder.

MOSES, WILLIAM H., Chairman of the Department of Architecture and Engineering, Hampton Institute, Hampton, Va. Henry Shivar, R. K. Downing.

MURRAY, RAYMOND L., Professor of Physics, N. C. State College, Raleigh, N. C. C. H. Beck, J. F. Seely.

NEMEROW, NELSON L., Assistant Professor of Civil Engineering, N. C. State College, Raleigh, N. C. W. W. Boyer, R. E. Fadum.

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O'STEEN, DENNIS N., JR., Assistant Professor of Electrical Engineering, University of Alabama, Tuscaloosa, Ala. Herbert Kuengel, D. H. McLean.

PERRY, ISAIAH B., Associate Professor of Engineering Drawing, Hampton Institute, Hampton, Va. H. L. Shivar, L. K. Downing.

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POLLACK, HERMAN, Instructor in Manufacturing Process, Pratt Institute, Brooklyn, N. Y. Otis Benedict, Jr., K. E. Quier.

POST, JOHN, Manager of Industrial Relations, Continental Oil Company, Houston Texas. E. R. Baker, A. B. Bronwell.

REESE, DONALD W., Instructor in Graphics, Lafayette College, Easton, Pa. H. C. Hamilton, F. W. Slantz.

RICH, LUCIEN L., Assistant Professor of Engineering, Hampton Institute, Hampton, Va. H. L. Shivar, L. K. Downing.

SCHEFFEY, CHARLES F., Assistant Professor of Civil Engineering, University of California, Berkeley, Calif. E. P. Popov, A. S. Levens.

SCHMIEDER, ALBERT K., Associate Professor of Mechanical Engineering, Northeastern University, Boston, Mass. A. R. Foster, J. W. Zeller.

SCHOMAKER, JOHN A., Assistant Professor of Electrical Engineering, U. S. Naval Academy, Annapolis, Maryland. J. L. Artley, D. G. Howard.

SLANTZ, ROBERT D., Instructor in Electrical Engineering, Lafayette College, Easton, Penna. C. M. Merrick, H. C. Hamilton.

SNYDER, NICHOLAS H., Professor of Ceramics, Rutgers University, New Brunswick, N. J. E. C. Easton, M. T. Ayers.

STEINMANN, W. L., Assistant Professor of Electrical Engineering, University of Vermont, Burlington, Vermont. W. A. Kee, R. G. Sidle.

STONE, L. E., Personnel Manager, The Chemstrand Corporation, Decatur, Ala. R. F. McCoole, F. J. Curtis.

TRUAX, CHESTER N., JR., Instructor in Mining and Metallurgy, Lafayette College, Easton, Pa. Don Clark, H. C. Hamilton.

WILLNER, ERNEST S., Assistant Professor of Humanities, University of Illinois, Chicago, Ill. M. V. J. Dembski, F. W. Trezise.

ZIEMAN, CLAYTON M., Head of Department of Electrical Engineering, U. S. Air Force Institute of Technology, Dayton, Ohio. L. F. Lewis, W. J. Price.

389 new members elected this year

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTOR IN ELECTRICAL ENGINEERING for September, 1954, to teach undergraduate theory and laboratory. Opportunity from graduate work in electronics or control. Apply to Chairman, Division of Engineering, University of Rochester, Rochester 3, New York.

INSTRUCTOR IN CHEMISTRY (ENGINEERING Field) to take charge and build up department in an Eastern Technical School; preferably a man with advanced degree and some industrial experience, who desires to teach and has leadership ability. Opportunity for research. MR–2.

INSTRUCTOR IN ELECTRICAL ENGINEERING. Man who is familiar with electric power engineering and also who has some knowledge of electronics, preferably one with some industrial experience. For the right man, permanent position and advancement. MR–3.

PENNSYLVANIA STATE UNIVERSITY. Instructors for off-campus centers in electrical, structural, drafting and design subjects. Faculty participates in hospitalization, retirement, insurance, and tenure plans. Apply to Terminal Study Dept., General Extension Bldg., State College, Pa.

HEAD OF SMALL AERONAUTICAL DEPARTMENT in large University. Must have real interest in education and demonstrated scientific capacity. Advanced Degrees or Industrial Experience essential. Send brief resume to AP–2.

INSTRUCTORS AND RESEARCH ASSISTANTS in the field of: Electronics, Experimental Stress Analysis, Mechanics of Fluids, Structures, Electrical Machinery, Mechanics of Solids, Microwaves, Thermodynamics, Transonic, Supersonic, and Subsonic Wind Tunnel Experimentation. Positions are for ½ time work—¾ time study or ¾ time work—½ time study, leading toward M.S. or Ph.D. degree. Salaries for June graduates are adequate and account is taken of experience and special qualifications. Write to: D. C. Drucker, Chairman, Division of Engineering, Brown University, Providence, R. I.

INSTRUCTOR IN GENERAL ENGINEERING, to teach engineering drawing, descriptive geometry and other subjects. Engineering degree required. Appointment to begin Sept. 1, 1954. For further information write to R. P. Hoelscher, Room 200 Transportation Building, University of Illinois, Urbana, Ill.

ASSISTANT PROFESSOR OF MECHANICAL Engineering to instruct undergraduate students in basic courses. M.S. degree plus teaching and/or industrial experience. Send applications to J. T. Strate, Head of Mechanical Engineering Department, Colorado A & M College, Fort Collins, Colorado.

INSTRUCTOR OR ASSISTANT PROFESSOR in field of Manufacturing Processes and Production Engineering: To act as Field Representative of Engineering Research Department to small industries and also to teach in Department of Industrial Engineering. AP–1.

Do You Know—

▶ The Graduate Study Division is investigating the possibility of undertaking a comprehensive evaluation of engineering education at the graduate level. There have been several previous studies of graduate level education, but these have not attempted to establish curricular goals or make recommendations with respect to subject matter. They were directed primarily at studying some of the major policy matters as they relate to graduate study. It is expected that this new project might be shaped up at the Annual Meeting at Urbana.

▶ A small writing committee completed preparation of the Interim Report of the Committee on Evaluation of Engineering Education at Raleigh, North Carolina on March 29. This draft, which will be sent to Institutional Committees for comments and criticisms, embodied the principal recommendations of some 118 institutional committees as well as the ASEE Committee on Evaluation at its Atlanta meeting. Copies of this report will be available at the Annual Meeting. The Tuesday morning General Session will feature a panel discussion by members of the committee, as well as discussions from the floor. There will be opportunities to present questions to panel members.

▶ The Annual Meeting plans this year portend one of the most important meetings in the history of the Society. The report of the project Evaluation of Engineering Education will be prominently featured in the General Session, as well as in many of the Division Meetings. The Division and Committee Programs, for the most part, are picking up some of the vital challenges facing engineering education as a consequence of new developments in science and technology. Over one hundred papers dealing with many vital phases of engineering education will be featured in these programs.

The ECRC and ECAC are holding a joint dinner in commemoration of the fiftieth anniversary of the founding of engineering experiment stations in this country. Dr. Lee DuBridge is the speaker. The dinner will be open to all those who wish to attend. An exhibit of research contributions is being planned.

Two of the General Sessions of the Society deal with "Creativity in Engineering" and "Recognition and Incentives for Good Teaching." The speaker at the Annual Banquet this year will be Major Lenox Lohr, President of the Museum of Science and Industry in Chicago. Major Lohr is a forceful and provocative speaker and we are assured of an outstanding banquet address. Incidentally, it was Major Lohr who organized and planned the very successful World's Fair in Chicago in 1933, which was the forerunner of World's Fairs all over the country.

The local committee at the University of Illinois, under the chairmanship of Lisle Rose, has done a superb job of planning the facilities and recreational activities for this Annual Meeting. They have determined to make this Annual Meeting a long remembered event. The ladies committee, under the chairmanship of Mrs. Lisle Rose, has outdone itself in planning a cultural and entertaining program to entrance the ladies. Mrs. W. L. Everitt, who is in charge of the children's program, has planned extensive activities which will fascinate the

youngsters of all ages and which will give the ladies an opportunity to break away from the family ties and enjoy their part in the program.

► You will be interested in reading the report on the Solid State Physics Symposium, Summer Institute Conference which was held at the University of Illinois on March 8–10, 1954. Those who attended the Conference felt that this was a highly successful venture and that it can point the way to significant improvements in certain areas of instruction in engineering curricula. A conference open to ASEE membership will be held at Carnegie Institute in Pittsburgh on June 21–25, 1954. For further information write to Asst. Dean John Grant, Carnegie Institute, Pittsburgh, Pennsylvania.

► As this issue of the Journal goes to press, plans are being completed for a similar conference of experts in Nuclear Physics in Engineering Education to be held at Columbia University on April 21–23, 1954. This will be followed by an open conference on the subject at Northwestern University on September 7–11, 1954. If you are interested in attending this conference please write to Professor Robert Young, Technological Institute, Northwestern University, Evanston, Illinois.

► May we call your attendance to the six Summer Schools being sponsored this year by the ASEE, the largest number in the history of the Society. If you are interested we recommend that you apply early, since attendance will be limited at some of these Summer Schools.

The Engineers Joint Council, which has been making substantial progress on a number of national problems bearing on engineering, is concurrently considering the possibility of developing a plan of regional affiliations and individual memberships. The regional affiliations would consist of engineering societies in the various regions of the country. The individual memberships would be on a voluntary basis and the members would receive a publication featuring articles dealing with problems which are of interest to engineers as well as views on national problems which relate to engineering. This proposal will be submitted to the constituent Society for their vote before any definite action is taken.

► Two new Branches of the ASEE have been authorized this year by the Executive Board. The Branch at the University of Illinois (Chicago Campus) is off to an excellent start with such programs as "What the ASEE is Endeavoring to Do," "Metallurgy in the Production of Cast Iron," "The Cooperative Plan in Engineering Education," and "Administrative Policies and the Faculty." Top-notch speakers have been featured at these meetings.

A new Branch has just been authorized at Purdue University. Two of the three top officers are assistant professors, attesting to the vigor and imagination of youth. We welcome both of these Branches into ASEE participation. Their positive approach in matters relating to the improvement of engineering education and the engineering profession will be a source of strength to the ASEE in the years ahead.

► We'll see you at the Annual Meeting.

ARTHUR BRONWELL, *Secretary*

Annual Meeting, June 14–18, 1954

University of Illinois
College of Engineering

By ROSS J. MARTIN

Associate Director, Engineering Experiment Station

The twenty-two buildings that house the current operations of the University of Illinois' College of Engineering will be open for inspection during the 62nd Annual Meeting of the Society, June 14-19, 1954. In addition, special displays will show growth of the College and its Engineering Experiment Station from their beginnings.

The College of Engineering was organized in 1870 to provide "courses in Mechanical Science and Art, Civil Engineering, Mining Engineering and Metallurgy, and Architecture and Fine Arts." Today it has departments devoted to the study of aeronautical, agricultural, ceramic, chemical, civil, electrical, general, mechanical, industrial, mining and metallurgical engineering, physics, and theoretical and applied mechanics.

Together with an expanding scope, the College of Engineering has grown physically from a single shop in 1895 into a well-integrated campus of twenty-two buildings, the newest of which are the Electrical Engineering, Mechanical Engineering and the Chemical Engineering buildings.

The faculty and student body have grown along with the college. Contrasted with the first graduating class of 1872, which included six engineering students, is a present enrollment of 2203 undergraduates and 570 graduates. The faculty, which consisted of a single man when the college was begun, had swelled to a staff of seventeen professors and assistant professors by 1900. There are now 372 full-time faculty members and a total staff of 583 in the College of Engineering. Although the college has grown, classes are still small and there is a continued effort to have close contact between students and their instructors.

The heritage of an early emphasis on those educational aims which today are regarded as primary is indicated in a passage from the University catalog of 1891–92: "A considerable portion of the courses of study must be devoted to general and literary work, since a graduate is now expected to arrange his ideas in clear order, and to write and speak effectively wherever it becomes necessary." The common program for freshmen follows out this idea. During his sophomore, junior, and senior years, the student's outlook is further broadened by his taking non-technical courses as electives outside his department of specialization.

Engineering Experiment Station

Stillman Williams Robinson, the first teacher in the college, believed that mathematical theory and scientific research should be blended with discussions of engineering practice—a philosophy of education still considered sound policy. Through the years the college has felt that research should go hand in hand with engineering instruction on both the

undergraduate and graduate levels. It was to expand experimental work, improve methods, coordinate efforts, and centralize the direction of experimental activities that the Engineering Experiment Station was established in 1903–04. (Iowa State and the University of Illinois will jointly celebrate the 50th anniversary of their experiment stations at the Annual Meeting.)

Since publishing its first bulletin, A. N. Talbot's "Tests of Reinforced Concrete Beams," in 1904, the Engineering Experiment Station has issued 422 bulletins, 65 circulars, and 50 reprints. Among the older continuing projects of the station are studies of railroad rails, heating and air conditioning, high speed tool steels, and boiler water treatment for power boiler equipment. Currently over 200 research programs are in progress with annual expenditures of over three and a half million dollars. In addition to studies vital to our present defense program, research is being conducted on transitors, tool steels to resist high temperatures, nuclear and solid state studies, structural engineering, and the effects of radio-active sewage on present-day treatment techniques.

Talbot Laboratory is among the outstanding laboratories on the engineering campus. The department of Theoretical and Applied Mechanics and some portions of the Civil Engineering department are housed in this building. In a 40×147-foot room in the central portion of this building is located the 3,000,000-pound Emery-Tatnall materials testing machine which has a vertical height sufficient to accommodate specimens 38 feet long for testing materials in tension and compression. The laboratory also contains numerous machines for studying materials under repeated loads, in bending, tension, compression, torsion, and impact.

Special Laboratories

The 10,000-cycle network analyzer, designed and constructed to solve power distribution and other network problems, is located in the new Electrical Engineering building. Special laboratories for studying electrical circuits, electrical measurements, and servomechanisms are also located in this building. An intensive research program in the field of physical electronics—transitors, semiconductors, millimeter and microwave propagation and antennas—is housed in the Electrical Engineering Research Building.

The new Mechanical Engineering building contains one of the most modern internal combustion laboratories in the country. It houses gasoline and diesel engines connected to dynamometers for performance testing. There is also a full-scale engine testing room containing an air-cooled aircraft engine connected to a dynamometer. Intake and exhaust pressures can be changed to simulate altitude conditions from 1000 feet below to 20,000 feet above sea level. Temperatures can be varied from -40 degrees to 150 degrees Fahrenheit. This building also houses laboratories for research and study in heat transfer, thermodynamics, precision measurements, machine design, and control systems, as well as the machine shop and welding laboratory for student instruction.

Other points of interest are the million-dollar Illiac, the electronic digital computer of the University of Illinois, located in the Engineering Research Laboratory, the shock tube in the Aeronautical Engineering Laboratory, and the 300-million electron volt Betatron housed in the Physics Research Laboratory.

Members of ASEE and their guests may visit these and other buildings and laboratories which will be open for inspection throughout the week of the Annual Meeting.

In addition, those coming to or returning from the Annual Meeting via Chicago will wish to visit the facilities of the Chicago Undergraduate Division at the Navy Pier. Established in 1946,

the Division includes a flourishing department of engineering sciences with an enrollment of 1172. The first two years of work are offered in virtually all fields in which engineering undergraduate instruction is given at Urbana-Champaign.

Relations between the Chicago and downstate campuses are close. The Navy Pier has active representation on the Executive, Policy and Development, and other committees of the College of Engineering. Just as important to ASEE members, the Pier is well represented on all host-institution committees for the Annual Meeting, and also will itself serve as host to the Mechanical Engineering Division Summer School of June 18–25.

Sections and Branches

The **National Capital Area Section** of ASEE held its Mid-Year meeting on 2 February 1954 at the Whittall Pavilion, the Library of Congress, Washington, D. C. with about 60 persons present.

After reports from Secretary-Treasurer Ojalvo and sectional YET sub-chairman Artley, and announcements of committee members and various Section activities by Chairman Walther, the main part of the meeting was turned over to a presentation of two papers on "Engineering Services and Facilities of the Library of Congress" by:

(1) Dr. Raymund L. Zwemer, Chief of the Science Division, The Library of Congress
(2) Mr. Robert S. Bray, Deputy Chief of the Technical Information Division, The Library of Congress

Dr. Clement R. Brown, Head of the Bibliography Section, Technical Information Division, The Library of Congress, introduced the speakers. In his paper entitled "General Services of the Library," Dr. Zwemer presented a short history of the Library of Congress, and talked about acquisition of science publications, bibliographical controls, mechanical and electrical aids for the librarian, and some mechanical aids for delivering information.

Mr. Bray's paper on "Special Services of the Library" covered: photo duplication service, card division, consultive services, the Technical Information Division, and special libraries in the Washington, D. C. area.

There was not much time left for a question and answer period; however, Mr. Ralph Goetzenberger made some pertinent remarks about the need of good library facilities in the area if Washington, D. C. is to become the science and technology center of the United States. Mr. Goetzenberger described the movement of professional and business people to bring the Engineering Societies building to the District of Columbia.

ASEE Summer Institute Conference on Solid State Physics in the Engineering Curriculum

By GLENN MURPHY

Conference Secretary, Professor and Head of Aeronautical Engineering, Iowa State College

Editor's Note:

This conference, sponsored by ASEE, the National Science Foundation, the University of Illinois and Carnegie Institute, is the first of a series of Summer Institute Conferences to be undertaken by ASEE.

The purpose of the Summer Institute program is to bring together some of the leading authorities in certain specialized areas where there appear to be possibilities of effecting substantial improvement of engineering education. The conference reported here will be followed by an open conference at Carnegie Institute on June 21–25, 1954. For information on this conference, write to Professor John Graham, Carnegie Institute of Technology, Pittsburgh, Pa.

On March 8, 9 and 10 about two dozen engineers and physicists met at Robert Allerton Park in Illinois under the chairmanship of Dr. Frederick Seitz of the University of Illinois to discuss the relationship of solid state physics to undergraduate engineering curricula. The conference was sponsored by ASEE with the active and generous support of the National Science Foundation.

The Allerton conference was organized because of a clear recognition that the present potential contributions of solid state physics to a better understanding of engineering materials need to be emphasized. The indications are that more engineering teachers should be made aware of the potentialities of the field. The principles of solid state physics are being applied today in electrical engineering for a better understanding of semiconductors, ferrites, transistors and similar items, and applications in metallurgy are advancing the technology of metals. What is already known of the phenomena of creep and fracture of materials will have profound influences in mechanical and civil engineering design when applied in these fields.

With the technical information now available, and with the expressed interest of the Evaluation Committee of ASEE in solid state physics, it appeared to be an appropriate time to initiate a conference in the field. Similar previous conferences on unit operations, electronics, microwaves and servomechanisms have been highly successful and have had a marked influence on engineering education in the respective areas.

The basic purposes of the Allerton conference were to determine what some institutions are doing about education in this field, to consider what should be included in a course in solid state physics for engineers, and to formulate a program for a general conference on "The Impact of Solid State Science on Engineering Materials" to be held at Carnegie Tech in June.

Present Offerings in the Field

About half of the time at the Allerton conference was devoted to a consideration of the course offerings in solid state physics by various institutions. These included colleges and universities and two of the industrial organizations, General Electric and Bell Laboratories, that have training programs for newly hired engineers and scientists. From these presentations some general conclusions (applicable to the institution represented, at least) may be drawn.

1. The amount of modern physics or atomic physics included in the freshman or sophomore course in physics is small, varying from 6 to 10 clock hours in most institutions.

2. Junior or senior level courses including instruction in solid state physics are generally available. Whether they are in physics departments or in engineering depends largely on the affiliations of the individuals who are interested in developing the field.

3. A course in solid state physics is required of all engineers at a minority of schools; it is sometimes required of metallurgical engineers and more frequently of electrical engineers.

4. Most of the schools represented reported that some instruction in semiconductors, transitors and the like was incorporated in electrical engineering courses taught in the EE department.

5. Relatively few schools give laboratory instruction in solid state physics.

It was the consensus of opinion that instruction in atomic physics as a foundation for solid state physics is essential in some curricula and highly desirable in others. In the years ahead our engineering students will require a better understanding of the science of materials. This means that the emphasis in materials courses needs to be shifted from the handbook type of information to the principles of behavior of materials under various conditions of use. It appears that relatively few engineering teachers are thoroughly familiar with what is known in the field today and with the applications being made. In order to raise the level of instruction

Electrical Engineering Building University of Illinois

in this area it appears to be highly desirable to bring to the instructors a summary of recent developments in solid state physics together with an interpretation of the engineering significance of these developments.

The space-time problem, or the problem of fitting any new or additional concept into already crowded curricula, is recognized as a critical problem, and one that can best be solved on an individual basis by each institution.

Suggested Courses in the Science of Materials

Approximately one-half day was devoted to a consideration of course content, as a result of which two course outlines were evolved. One outline contained what might be taught in a one-semester, three-credit course in atomic physics and solid state science; the other involved a sequence of two three-credit courses—the first in atomic physics and the second in solid state science.

The items suggested for the one-term course outline included structure and size of atoms, crystal structure, alloy formation, discreteness of atomic levels, one-electron spectrum, Pauli exclusion principle, energy bands, electrons and holes, imperfections, vacancies, semiconductors, and dislocations.

It was considered that a course of this character, which is about one-third atomic physics and two-thirds solid state science, would give the student a picture of what solid state physics can do in his field, but is insufficient to emphasize the limitations. However, it should give the student a working vocabulary in the field and enable him to read articles on new developments, and to understand general applications of principles.

In the two-term sequence the topics suggested as being appropriate for the first term (on atomic physics) were the atomic nature of matter, fundamental particles, quantum nature of light, thermal radiations, atomic spectra, atom complex, periodic table, X-rays, wave nucleus, nuclear structure and nuclear reactions.

The second term, on solid state physics, should probably include crystal structure, building forces, mechanical and thermal properties, electrical conductivity of metals and semiconductors, dielectric properties, magnetic properties, surface properties.

The two courses outlined have essentially the same content as existing courses given by Bell Laboratory and by various universities. Several different arrangements for teaching the course or courses were discussed, ranging from a one-term course taught in physics to two one-term courses given in various engineering departments. The group was of the opinion that it was relatively unimportant where the courses were taught provided that the instructor was well qualified and thoroughly grounded in the basic modern and solid state physics.

However, there appeared to be general agreement that these courses should be given different emphasis when taught to engineering students than when taught to physics majors. For the engineering students the body of knowledge and its applications should be stressed rather than the historical development of the principles and the fine details of the derivations. However, the courses should be directed toward giving the student an understanding of the principles and not merely their application. That is, they should be directed toward forming a basis of education in the science of materials rather than being additional training in solving problems.

The Carnegie Tech Conference

The remainder of the program was devoted to the general formulation of the conference to be held at Carnegie Tech on "The Impact of Solid State Science on Engineering Materials." The general theme of the conference is to be "what is the basic content of solid state physics

and what does it have to offer the engineer?" The conference is to be set up primarily for engineering teachers to give them a picture of how the new developments in solid state physics are related to and can be utilized in modern courses in engineering materials and allied subjects.

As now planned, the first day of the conference the last week in June will be devoted to "Fundamentals of Fundamentals." An opening talk will be given on the basic structeure of matter, binding forces and similar fundamental concepts. This will be followed in the afternoon with a survey of the properties of materials and an open discussion of materials and the solid state.

The Tuesday morning session is to be devoted to metals, introduction to metallic compounds, and general properties such as precipitation hardening. In the afternoon, polymers, ceramics, and cements will be discussed.

The mechanical and thermal properties of materials will be the subject of the discussion on Wednesday, with Thursday being devoted to the electrical and magnetic properties.

Surfaces of materials will be discussed on Friday morning with special attention to absorption, catalysis, and corrosion, and on Friday afternoon the conference will close with a general summary of the field of materials as related to our knowledge of the solid state.

Because of limited facilities, the conference will be limited to 150 individuals. It is hoped that engineering teachers interested in the new developments in the field can attend.

The Allerton conference closed with the adoption of the following resolution.

University of Illinois Conference on Solid State Physics in Engineering Education

Resolution

Recognizing the need for a scientific basis for the understanding of the properties of materials and for the effective use of such knowledge in the solution of engineering problems, it is the sense of this conference

I. that all engineering curricula include material on structure of matter,

II. that all engineering curricula in their advanced courses take cognizance of this physical basis of the properties of materials,

III. that the implementation of these objectives be achieved through the cooperative efforts of engineering and physics departments at each institution.

The conference recognizes fully that local situations will influence the realization of the stated objectives.

One possibility might be a course of approximately 3 semester hours in the junior year based on general physics and possibly ordinary differential equations as prerequisites and including the following topics:

Crystal Structure
Binding Forces and Crystal Types
Mechanical and Thermal Properties
Electrical Conductivity
  (*a*) Metals
  (*b*) Semiconductors
  (*c*) Salts
Dielectric Properties
Magnetic Properties
Surface Effects
Phosphors and Photoconductivity

Regardless of the department in which such a course might be offered, its objectives definitely should be oriented to meet the needs of engineering students. To insure understanding of the concepts involved, it might be desirable, though

not essential, that such a course be preceded by a course of approximately 3 semester hours on atomic physics, based on the same prerequisites and including the following topics:

Atomic Nature of Matter
  (*a*) Kinetic Theory
Fundamental Particles
Quantum Theory of Light
Atomic Spectra
  (*a*) Energy Levels
  (*b*) Spectroscopy
  (*c*) Periodic System of Elements
X-rays
Wave Nature of Matter
  (*a*) One-dimensional Wave Equation
Atomic Nucleus
Molecular Structure
  (*a*) Valence Bonds

Should it not prove feasible to offer this introductory course on atomic physics, part of the topics listed for it might be included in the outline of the material on Structure of Matter.

The individuals recorded as being in attendance at the Allerton conference were the following.

Frederick Seitz, Physics, University of Illinois
Dan H. Pletta, Head, Applied Mechanics, Virginia Polytechnic Institute
John W. Graham, Jr., Ass't Dean, Eng'g & Science, Carnegie Tech
J. E. Goldman, Department of Physics, Carnegie Tech
A. B. Bronwell, Secretary, ASEE, Northwestern University
B. R. Teare, Jr., Dean, Engr & Science, Carnegie Tech
John C. Slater, Department of Physics, M. I. T.
W. Crawford Dunlap, Jr., G. E. Research Lab, Schenectady
Ray Pepinsky, Research Professor of Physics, Pennsylvania State University
William G. Shepard, Department of Elec. Engr., University of Minnesota
Earl R. Parker, Professor of Metallurgy, University of California
T. A. Read, Department of Metallurgy, Columbia University
G. C. Danielson, Professor of Physics, Iowa State College
P. H. Miller, Jr., Professor of Physics, University of Pennsylvania.
Sidney Millman, Physical Research Department, Bell Telephone Labs
A. W. Lawson, Department of Physics, University of Chicago
M. J. Sinnott, Chem & Met. Engr., University of Michigan
K. Lark-Horovitz, Physics Department, Purdue University
L. M. K. Boelter, Dean, College of Engineering, University of California
F. S. Buffington, Engineering Division, California Institute of Technology
R. J. Seeger, Math, Phys, Engr Sciences, N S F
Ernst Weber, Head, Department of Electrical Engr, Polytechnic Inst. of Brooklyn
W. L. Everitt, Dean of Engineering, University of Illinois
Eric A. Walker, Dean of Engineering and Architecture, Penn State
R. C. Retherford, EE Department, University of Wisconsin
John Bardeen, EE and Physics, University of Illinois
Loyd P. Smith, Physics, Cornell University
J. D. Ryder, Electrical Engineering, University of Illinois
Glenn Murphy, Head Aeronautical Engr, Iowa State College

Industry's Interest in More Education for Engineers*

By L. E. GRINTER

President of ASEE, Dean of the Graduate School and Director of Research, University of Florida

There is indeed a striking comparison between the interest shown in the young engineering graduate today and twenty-five or thirty years ago. Today industry makes clear in many ways its intent to use every device for making the first five years of the graduate's industrial association contribute to his individual effectiveness When I took my first industrial job my employer made it clear to me that he was merely experimenting and that he seriously questioned whether the investment of time in training a college graduate in the ways of industry would ever pay off. After a few months I myself decided that his experiment was going to be a failure, not because I couldn't learn the ways of industry, but because he did not appreciate sufficiently the usefulness of basic engineering science—so I quit the job and went back to school.

It is worth noting that I had to quit the job to go back to school. If any evening graduate courses were given in Pittsburgh, where I was employed at that time, I was not made aware of them. If the idea of cooperative graduate study on a part-time basis existed, it was not general information. Certainly my employer had no feeling of responsibility for my further education except as an apprentice. I may have helped educate him because he seemed amazed by my decision to quit a steady job for further education. He remarked that he had fired a lot of men in his time but that I was the first one who had quit without a reason. To salve his pride he withheld a hundred dollars of my salary which he classified as the value of company effort toward my apprenticeship training. I quote this case to point out the great change that has occurred over thirty years in industry-employee relations.

Continuing Education Needed

Since we are restricted in the university by a curriculum of quite limited extent, it is necessary for the graduate to continue his education after leaving the university. He needs at least three kinds of continuing education:

(1) Special training for the job that he holds or expects to hold. This is exclusively the problem of industry since no college can effectively teach company techniques and practices.

(2) Further education in engineering or allied subjects. Evening graduate courses are provided in large cities, and home study is always available to ambitious people. Also, many progressive companies have cooperative arrangements with universities for the conduct of special courses or educational programs.

* Presented at the College–Industry Conference sponsored by the Relations With Industry Division of ASEE, Detroit, Michigan, Jan. 16, 1954.

(3) Further breadth of education is essential for good citizenship which demands a broad understanding of people and the instruments of government, polities and economic institutions.

The responsibility for these three types of continuing education is a joint responsibility of the young graduate, the employer, the university and the engineering societies. All of these influences exist, but at times they have been operating at cross purposes. No individual can react favorably if he is being pulled in three directions at the same time, which is the situation if there is no plan as to how the individual graduate can advance his three-fold education, first for his immediate job, second toward greater depth in engineering, and third toward a more liberal education.

I have long believed that interest should dictate the immedate direction of each individual's education. Whenever we find a young person studying engineering merely because his father is an engineer or an engineering professor, we know that his chances of success are limited. Of course, interests change. Every teacher has the occasional experience of having some of his brightest graduates return and admit freely that they have carried on no engineering studies after graduation. The emphasis upon training for the job has separated these graduates from their profession, and once the continuity of interest in engineering study is broken it is not likely to be re-established.

A great deal of emphasis is being placed upon counseling of college student, but it does not appear that an equally effective system exists in all industry. The graduate's boss can not ordinarily serve as an effective counselor because the boss has immediate problems to be solved that require certain types of training which he must necesarily urge upon the new employee. The counselor should have a broader viewpoint based upon the long term needs of the company for people of all backgrounds of education. Such an individual can try to determine the interests of the young engineer and counsel him to seek further education that will provide an outlet for his interests either within the company or elsewhere. There is small merit in ruining a potential professional-scientific engineer to produce a mediocre executive or *vice versa.*

Creative Engineers in Short Supply

It is my belief that industry's greatest shortage of engineers during the next ten or fifteen years will be in the field of creative, professional or scientific work. *Engineers competent to produce creative results in research, development work and design are certain to remain in short supply no matter whether the total number of engineers becomes adequate or remains critical.* A person with long experience in the field of commercial art mentioned recently that no more than one student in ten who enters that field can be depended upon for creative work in art. I fear that about the same ratio of one in ten will limit our production of creative designers and of research and development engineers. Of course, all engineering demands a modicum of creativity since even maintenance work is seldom repetitive. However, an exceptionally high level of creativity is required for the production of research and development or novel design work. Such creative minds will always be in short supply.

To an increasing extent the possibility of developing new ideas, concepts, processes or even new hardware for industrial production requires knowledge of the engineering sciences. *Statics including elasticity and plasticity, dynamics, including vibrations, fluid flow, heat flow, thermodynamics including combustion, electric flow, electronics and electric waves, physical metallurgy and the properties of engineering materials form the*

background engineering sciences. These engineering sciences rest upon the basic sciences of mathematics, chemistry and physics, including in the near future nuclear physics and the physics of the solid state. No graduate of a four-year curriculum is likely to have an adequate background of the basic sciences and the engineering sciences if his job is to become a creative engineering scientist for industry or even a design engineer.

It is my suggestion then that industry scan most carefully its new recruits from the colleges of engineering to determine which ones have the interest and the ability to continue their education in engineering science. When located, these individuals represent a large fraction of the industrial potential for future creative activities including product development. It would be my thought that such individuals should all be given the opportunity and encouragement to complete their studies for the master's degree, and in more limited numbers to obtain the doctor's degree. Industry can well afford to invest much more heavily in the training of future creative personnel since it is unrealistic to expect young men who have already invested an average of four years and 5000 dollars in a B.S. degree in engineering to be willing to face a large added expense for graduate education without earned income. The Armed Services have long recognized the necessity of providing such training for officers wherever needed.

Educational Opportunities

When large industries face the problem of continued education for employees they find several opportunities. Sources on an evening school basis may be available near the plant or at cities within driving distance. If so, the typical rebate of tuition by the company may be adequate inducement for students who are taking undergraduate courses or courses for general education, but is is a rather negligible contribution to the graduate study of engineers. This problem needs to be restudied. For example, company fellowships for full-time graduate study of selected employees should be considered. A company may also decide to arrange with an educational institution to conduct graduate courses and special courses at the plant, or nearby, for Company students. When approached with the undertsanding that long-term educational benefits are being sought, rather than particular job training, such academic programs have real value and have been conducted successfully.

A very large company or industry may feel that it can afford a Company Institute for the training of its employees. There are examples in the automotive industry and also in the Federal Government. At a recent meeting at which a group of educators including industrial representatives were drawn together to study this problem in its relation to Federal Agencies it was concluded that the granting of degrees should not be sought by such agencies, and I am sure that the same arguments apply to industry. The immediate desire for job training is too influential in a non-academic atmosphere; the feeling of the student that education so provided must be necessary to his advancement is likely to result in classes filled with students of mediocre qualifications. There is also a lack of stability in the too frequent use of part-time teachers resulting in typically large drop-outs from classes. Academic institutions have long experience in avoiding such problems, which is really the basis of maintaining high academic standards.

With more than one hundred and sixty accredited colleges of engineering available in this country no company need fail to obtain academic sponsorship for any educational program which it desires to have conducted on a graduate or undergraduate level. However, the company should not approach a university with the idea that it can have university sponsorship and still dictate the

program itself. *The reason for university sponsorship is to obtain an impatrial influence upon the educational program that keeps it above the level of an industrial training program.* If the latter is desired, the program should be concluded by the company on a non-credit basis. *But if graduate or undergraduate credit is desired for application to a university degree, the final decisions concerning the selection of the teacher, the course content, the prerequisite study and the selection of students can only be made by the university sponsoring or operating the program.* When this necessity is clearly recognized, a working relationship should not be difficult to achieve. I believe that we need many more cooperative company-university programs at the graduate level in many engineering fields.

College Notes

The administration of teaching and research in engineering at the **University of Pennsylvania** has been completely reorganized in order to coordinate and extend the University's activities in these fields. Under the reorganization the Towne Scientific School has been divided into four separate Schools of Chemical, Civil, Mechanical and Metallurgical Engineering, each of which will have its own faculty.

Directors have been named to head the four newly-created schools and the Moore School of Electrical Engineering, while two assistant vice-presidents for engineering also have been appointed. All of these various engineering units will function under Dr. Carl C. Chambers, vice-president in charge of engineering affairs. In addition, provision has been made for the establishment of an Institute for Cooperative Research to stimulate, coordinate and manage investigative activities in the engineering field for industry, foundations and government.

Appointed directors of the five engineering schools are Dr. Melvin C. Molstad, Swarthmore, Chemical Engineering; Emory F. Stover, Gladwyne, Civil Engineering; Lee N. Gulick, Bala-Cynwyd, Mechanical Engineering; Dr. Robert M. Brick, Bryn Mawr, Metallurgical Engineering, and Dr. John G. Brainerd, West Chester, Moore School.

Industry, Engineers and the First Five Years of Professional Development*

By DR. L. F. GRANT

Chairman, Engineers' Council for Professional Development

As I am here in my capacity as chairman of the Engineers' Council for Professional Development, hereinafter referred to as ECPD, I shall confine myself to a discussion of the "First Five Years of Professional Development," commonly known as the Monteith Report, and, as it is expected that out of this meeting will grow one of the courses which that report contemplates, I think it well to tell you something of its history.

The ECPD was formed with the idea of developing the engineer in successive phases, and not of developing the profession. The first of its objects was to give adequate counselling in schools to boys who were considering entering engineering colleges. When I was a youngster, no such advice was available. Some of the older men present may remember a book about engineers written by the late Richard Harding Davis. It was a first-class adventure story and depicted the hero—an engineer—running a transit with one hand and standing off a gang of desperadoes with a gun in the other, and on the penultimate page marrying the daughter of the president of the railroad. I suppose that book was responsible for producing a larger crop of mediocre engineers than any other influence I can think of. The second was to examine and accredit the various curricula offered throughout the country to see whether they were thoroughly efficient. Now, having dealt with the boy before he goes to college, and having tried so far as is possible to make sure that the young man's college course is a satisfactory one, we come to the third of the ECPD objects, and this is the one with which we are concerned today, namely development after graduation. In this for a long time we made no progress. I myself, was chairman of a similar committee in Canada and for several years I did my utmost to try to find out what the profession can do for the young engineer—entirely without success.

What does he want? He wants a better job, and by that I do not mean of course simply more pay, but work that will constantly be a challenge to the best that is in him, that will call upon him to improve his professional knowledge, his outlook on affairs outside of the profession, and to increase his usefulness to society in general and to his employer in particular. Obviously for any organization to achieve this is a difficult task, and when in the course of time I became the Canadian representative on the ECPD Committee in charge of this project I found that whereas I had been trying for three or four years in Canada to effect some result and had got nowhere, the ECPD, had been trying for a much longer time and had got to exactly the same place.

Finally in 1949, the then chairman of the ECPD (and I am particularly glad to make this statement here) a well-

* Presented at the Relations with Industry Division, ASEE meeting at Detroit, Jan. 16, 1954.

known citizen of Detroit—Mr. James Parker of Detroit-Edison—said that he was tired of talking about this plan, that he would have a survey and a report made from which a programme could be designed and implemented, and if it was not possible to implement this programme, the ECPD should throw in its hand and decide that the project was beyond its powers.

Full Professional Stature

The eminent engineer who was chosen to make the survey and report was Dr. A. C. Monteith of Westinghouse. Dr. Monteith assembled a very competent committee of men who, as the foreword states, "were active engineers, busy in their field of endeavour, but anxious to help the rising generation attain full professional stature." Could one give any finer tribute to a group of engineers than those words?

I am glad to have this opportunity of expressing my admiration for and gratitude to them for the work they did. The report was a voluminous one.

The headings under which the "First Five Years of Professional Development" are discussed, are:

1. Orientation and Training;
2. Continued education of graduate engineers;
3. Integrating the young engineer into his community;
4. Registration of the young engineer;
5. Self appraisal methods for evaluating characteristics in engineering;
6. Reading list.

In order to produce this report a systematic survey was made of the training given by fifty-four companies in the United States which the committee classified as:

A. SMALL: those which normally employ five new young engineers every year;

B. MEDIUM: those which normally employ from five to twenty-five; and,

C. BIG: those which normally employ more than twenty-five new graduates, running in some cases into the hundreds;

beside these fifty-four companies the committee surveyed a number of others though less completely.

In nearly every case the big companies have some sort of formalized course, given in the company's time and at the company's expense. Some of the medium class are doing the same, but very few of the smaller ones are. It must be remembered, however, that in the small concern the young engineer will often obtain personal advice and direction which may well be as valuable as the more systematic courses which the larger companies are able to undertake. But obviously there are many young engineers who do not have the opportunity of receiving such beneficial training.

From the beginning it was realized that the project must have the support and co-operation of industrial leaders as well as educationalists, and it is a pleasure for me to say that every assistance possible was given to Dr. Monteith's committee by the industries interviewed, that this assistance has since been continued especially in Cincinnati where the first course is now being held, and the presence of so many industrialists here today gives further evidence that industry recognizes the need for further training of engineers if they are to make the most of themselves, not only for their own benefit, but for that of their employer.

Post-College Slump

The Report recognizes that all too many young men, when they graduate, fall into what has been called 'the post-college slump,' as a result of being removed from the affectionate care and sympathetic encouragement which they receive (especially at examination time) from us professors, and being then pitchforked into employment where the em-

ployer has the peculiar and heretical notion that the young man ought to be able to do something for himself. Some effort is needed at this stage to remind the young man that education is a continuing process (I apologize for using this somewhat shop-worn cliché but we do not seem to be able to get away from it), and that he has at least part of the responsibility for making himself more useful to his employer if he is to advance in professional responsibility and achievement.

Training thus becomes a triple partnership between industry, education, and of course, the young man himself. The constant support and the constructive and helpful criticisms which the ECPD receives from industry is most encouraging.

When the Monteith Report was presented to the annual meeting of ECPD at Cleveland in October 1950, it met with unanimous approval, and the question then became, how was it to be implemented? The main difficulty was to obtain a competent director, and after some delay the Council was very fortunate in obtaining the services of Professor Cornelius Wandmacher of the University of Cincinnati, who, after two years of hard preliminary work, inaugurated the first course in October of 1953. The details of that programme will be explained later and I am going to touch on only two or three points.

The studies which are proposed are *mainly* those of engineering, and they may, if pursued long enough, lead to a Master's degree, and even if the student does not want to go so far as that, he will be able to refresh and extend his engineering knowledge and to do some work on a post graduate level. This part of the project is necessarily the responsibility of engineering teachers.

Now what can engineers in industry, and industrialists in general do to help in this program? Well they are so to speak, the ultimate consumers of the product of engineering colleges, a product which to the industrialist is only raw material or at least only patrially processed material. You industrial men can teach the young engineer what industry expects of him; you can show him how his university education must be implemented by application and by practical experience, and you can give him that knowledge of industrial problems and their solution, which the college cannot do. How welcome such instruction will be is illustrated by the remark of one young man who was a member of a group for whom I arranged a somewhat similar course. He said to me, "We have been listening to professors for four years, now we should like to hear from the man who is actually doing the work," for which admirable opinion I congratulated him warmly.

Labour relations, company finance and management, the many problems with which industry is faced, must also form part of such a course, and here industrialists are best fitted to give instruction.

Again the young engineer does not always appreciate his duties to his profession and to the community, and this is recognized by the Monteith Report in Points 3 and 4, "Integrating the Young Engineer into his Community," and "Registration for the Young Engineer."

Development of the Young Engineer as a Man

Finally it was found that nearly every company gave in its training something outside of engineering, something which had as its object the development of the young engineer as a man, or to use an old-fashioned expression of which I am very fond, "a man of parts," by giving him some of those things which he did not get at college, or which, if he did, he was inclined to disregard as not being exactly engineering. Such things may be a better mastery of the spoken and written word, a knowledge of current affairs, both national and international, political economy, possibly as we have

tried in Canada, some introduction to the appreciation of Philosophy, of Art, of Music, and of Literature, or even The Social Graces.

The young men who participate in such a course as is proposed, both on its technical and non-technical sides, will I am sure develop professionally as engineers, as citizens, and as men of parts, so that they may in time attain to the splendid ideal written by Bacon in his preface to "Maxims of the Law," in those rolling Elizabethan periods of which Bacon was such a master:

"I HOLD every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit, so ought they of duty to endeavour themselves by way of amends to be a help and ornament thereunto."

College Notes

New developments in engineering will be presented at the **Pennsylvania State University** through eight summer seminars. These include programs in Analog Computers, June 21–July 2; Color Television, June 21–July 2; Creative Engineering, June 21–July 2; Electrical Contacts, June 28–July 2; Electrostatic Precipitation, June 21–25; Mechanics of Creep, June 28–July 2; High-Temperature Properties of Materials, June 21–25; and Transistors, June 9–19. Outstanding guest lecturers will present the latest developments in these fields.

Enrollment is open to graduate engineers and scientists. Inquiries should be addressed to Prof. K. L. Holderman, 103 Mechanical Engineering Building, the Pennsylvania State University, State College, Pennsylvania.

The appointment of Dean Edward L. Cochrane as Vice President for Industrial and Governmental Relations and of Professor C. Richard Soderberg as Dean of the School of Engineering at the **Massachusetts Institute of Technology** has been announced.

A special one-week summer program in Corrosion, to summarize the fundamental and recent advances in this field, will be given at the **MIT** during the 1954 Summer Session, from June 21 through 25.

Dr. Herbert H. Uhlig, Professor of Metallurgy, will be in charge of the summer program.

Experience Tells Me*

By J. J. CRONIN

Vice President in charge of Manufacturing Staff, General Motors Corporation

A young engineer's first five years after college are, in most cases, rather long ones. As I recall it, they were for me, and I presume that I had all the problems which confront today's young engineers. Perhaps, like others today, I even went so far as to borrow some problems which did not exist. The pay in 1918 at Fisher Body for a young college graduate was thirty cents an hour, and while that was only equivalent to six hamburgers, I should say that in those days a hamburger came more nearly being a satisfying meal than does its namesake today. We worked hard and dreamed large dreams in those days just as young men do today. Similarly, we were concerned about such things as our financial progress on the job, our opportunity for advancement, our doubts as to whether our work was fully appreciated, and what we could do to better equip ourselves for tomorrow's hoped-for opportunity. I am sure that these or related problems are burdening the young engineer today.

To you as technically-minded men, my message may be disappointingly non-technical, yet this is the chance I take. I hold a great appreciation for each of the three fields which you represent but, with your permission, I would like to broaden the conventional definitions which each of your may hold for your callings or offices.

We generally think of engineers as exercising ingenuity in the design of things. I would like to extend the meaning beyond the "design of things" to include "the design of living."

We think conventionally of technical societies as existing primarily as a focal gathering point for those having a community of interest in a technology and for the dissemination of information with respect to that interest. Considering that such a group is in itself a segment of society and thus is made up in its membership of men and women with singleness of purpose, I would broaden the objectives of a technical society to include the techniques of better human relations.

Engineering educators are conventionally and properly thought of as learned folks shouldering the heavy responsibility of shaping young minds and instilling in their students the maximum of fundamental technical knowledge. I would like to lay down the challenge that engineering educators have the priceless opportunity of also helping the engineering student to shore up the crucible in which that knowledge is contained. Knowledge to be useful must be in the mind of a person of sound character or that knowledge might someday be wasted or misused.

Since I've warned you that my message will be non-technical, I'd like to tell you about a recent athletic event which took place at Briggs Stadium, Detroit. It is the home of our Baseball Tigers in summer and our Football Lions in the fall. Between Christmas and New Year's, an important athletic event took place there. The Cleveland Browns, champions of the Eastern Division of the National Football Confer-

* Presented at College Industry Conference, Relations with Industry Division, ASEE, Detroit, January 16, 1954.

ence, engaged our Detroit Lions, champions of the West. The two teams were evenly matched. Either could have been victorious or the contest could have ended in a tie and everyone, including the fans perhaps, would have been satisfied. A few days prior to the game, the quarterback and leader of the Cleveland Browns made a very significant statement to the press. This great team leader, Otto Graham, said that the league championship would be decided on the basis of "mental fitness." Translate "mental fitness" any way you wish and it adds up to a wholesome attitude—in this case, a wholesome attitude toward the job of winning a game.

From the spectators' standpoint, the game was a thriller and the championship was won by the slim margin of a point after touchdown, and I am sure that none of us in the stands would have wanted to shoulder Doak Walker's responsibility in kicking that all-important Detroit point, but he approached the job with a determination borne of right attitude.

Former President Theodore Roosevelt, a man who goes down in history as having a great depth of human understanding, left his permanent mark on our country. He left a nation proud of its own natural resources and a nation which had the righteous respect of an entire family of nations. He also left this significant account of his efforts as recorded by writer David Guy Powers.* Theodore Roosevelt said

I stood out for my opinion alone. My own conscience, my own judgments were to decide all things. I would listen to no arguments, no advice. Finally, I learned that the things I wanted to do, I was powerless to accomplish.

What did I do? I looked the ground over and made up my mind that there were several excellent people with honest opinions even though they differed with me. I turned in to help them and they turned to and gave me a hand, and so we were able to get things done. We did not agree on all things but we did on some and those we pulled at together.

You who are participants or guests at this conference know about the give and take of a meeting. You, too, may have had your individual differences during the day but I'm sure that you agree on the value of achieving the goal which has brought us together. In a way, the very fact that you have appeared here today indicates that you have a wholesome attitude toward the task. You recognize that a problem exists and are giving of yourselves to help arrive at a solution.

There is much in common among Otto Graham—the football quarterback—Theodore Roosevelt—the man who spoke softly more than he used the big stick—and you who are gathered here today. Otto Graham talked essentially about a wholesome attitude toward the job at hand—which in this case was the winning of a professional football game. Teddy Roosevelt spoke frankly about how he arrived at a wholesome attitude toward people. You who have come here to give of yourselves for the advancement of a worthy cause have exhibited a wholesome attitude toward living.

Successful Accomplishment

All action stems from our will to perform the action. The will grows from an idea which is allowed to develop or is extinguished by our judgment. If our judgment permits the idea to move to the stage of our determining to do something about it, the action is tempered by an elusive spark which is our attitude and our attitude can grow into a fierce flame which will determine the type or character of our action. Our attitude is the key element. A wholesome attitude underlies all successful accomplishment.

And it is at successful accomplishment

* From "Live a New Life," by David Guy Powers, copyright 1948. Reprinted by permission of Doubleday & Co., Inc.

that we aim when we discuss the engineer's first five years in industry. We —all of us—want to create a favorable climate for the young engineer so that he does not consider his work to be economic drudgery necessary to make a living but rather as an opportunity to develop and express his latent talents. We want the individual engineer to take maximum advantage of that climate and come to realize that his attitude toward work, toward living, and toward people will develop an inner satisfaction through personal attainment, attainment which is measured directly by the elastic limit of his abilities.

Have you ever paused to consider how tremendously our attitude effects our actions? We associate success with great actions whether they be sudden as in battle or on an athletic field or sustained over a lifetime as in the case of great statesmen. Men who translate their lives into great actions invariably exhibit wholesome attitudes.

Along the highway of life, each of us is attracted by some men of action, and invariably we admire them for certain personal traits. Notice how these traits are each an attitude—ambition, cheerfulness, confidence, courage, enthusiasm, integrity, loyalty, perseverance, self-control, understanding, and vision, to name but a few.

Each of these traits associated with success is the expression of a wholesome attitude toward people, toward work, or toward living generally. We are free, each of us, to assume or develop any or all of these traits. Similarly, we are free, each of us, to demonstrate a willingness to instill and develop these traits in the young men who come within the shadow of our influence.

The shadow of your influence may be longer than you think. In many ways, our founding fathers considered themselves as very ordinary folks and all of us today may look around us to see what their sound thinking has accomplished. Suppose for a moment that our founding fathers had set up a government such as that which has grown up behind the Iron Curtain. Could the same material advancement have been possible, even with our vast natural resources? History's pages are full of examples of nations which had the same material opportunity to prosper as had the United States but somehow did not achieve our benefits.

I am not one to place undue importance on our material advantages nor to say that anything American is necessarily the best in the world. However, I do certainly value and endorse the working climate of individual initiative which made our high living standard possible. Our founding fathers established a nation unique on the face of the earth because it advanced the proposition that man gets his rights from God and not from government. Between man and government, man is supreme. Man is free to make choices, good or bad.

Picture if you will the young engineer behind the Iron Curtain who could derive personal benefits from ambition, cheerfulness, confidence, generosity, integrity, and all the rest! Our young engineers—and all of us—still live under the shadow of the influence of our founding fathers. Our freedom gives us the right to life, liberty, and *pursuit* of happiness according to our own attitudes toward these three elements. We are free to demonstrate, live, and express our attitudes toward good—or evil —objectives; and our own attitudes can be very contagious.

What I've tried to point out so far is that a wholesome attitude underlies success in any venture and that we live in a unique nation where a wholesome attitude pays off for all of us. Let us try to apply a wholesome attitude to the task at hand: that of creating the right kind of climate for the young engineer in his first five years in industry —realizing, of course, that the young engineer by his work and attitudes will

bear the full responsibility for taking advantage of the opportunities available in this climate.

Industry and Education

In the area of education first of all, let us give honest recognition to the store of technical knowledge which the young man has gained on earning his baccalaureate degree in engineering. The knowledge is of sufficient value to us in industry so that we have completed briskly for next June's 19,000 graduates of U. S. engineering schools as we did for last June's 24,000 graduates. The Scientific Manpower Commission has indicated that we have a need in the United States for from 35,000 to 40,000 engineers right now and the Commission estimates that our needs to accomplish the nation's engineering tasks will continue at a level of about 30,000 new engineers per year for some time.

When engineering graduates come to us in industry, we assume a responsibility of carrying on where engineering educators leave off. While we in industry welcome and seek young engineers, we recognize that they are by no means finished products. You have trained them to *become* engineers; you were not expected to turn them out as *finished* engineers. The responsibility of undertaking further training programs is one which we gladly accept.

In our training programs, we have an excellent opportunity to discuss the value of graduate study as it might apply to each individual and in some cases we could recommend to the young engineer that he supplement his on-the-job training with formal graduate study. In General Motors, we operate under a policy of decentralized control and each operating unit establishes its own practices. But I know of no unit in which graduate work by young engineers is discouraged. In fact, we hear only of its encouragement.

Among the means taken by industry to promote the self-development of young engineers through graduate study programs are

(1) Reimbursement of tuition, provided certain requirements are met.
(2) Granting of graduate scholarships to employees.
(3) Granting to colleges and universities graduate fellowships which are filled by students who do not commit themselves to become employees of the industry which makes the grant.

Industry also promotes a closer liaison between engineering education and their employees through

(1) Bringing engineering professors into their laboratories and plants for summer work.
(2) Conducting of seminars in which professors are invited in as leaders.
(3) Conducting of conferences in which engineering educators are invited to a program of visits and lectures to better acquaint them with industry's viewpoints and to bring to industry a greater understanding of problems in engineering education.
(4) Sharing of technical information, such as we do in General Motors by providing engineer-lecturers for college classrooms and publication of a technical periodical for engineering educators.

Two Academic Camps

At a conference for engineering educators held by General Motors last summer, we learned that the educators are divided into two academic camps. One group feels that industry has grown so complex that it is no longer possible to specialize engineering education to a sufficient degree so that the graduate will be immediately profitable to industry. This group urges a return—or a continuing emphasis—on a thorough grounding in

the basic sciences. The second group feels that a student ought to be trained very thoroughly in a narrow technical field so that he can be immediately valuable in his specialty.

I have no particular preference for either academic viewpoint, and there are many others, both in my company and in industry generally, who have no strong preference either for a specialized education or a broad scientific training. The guests at our conference made a survey and appointed a spokesman from their number to summarize their findings. The Professor, from the University of Toronto, said in his talk given near the end of the 15-day conference

> The answer was quite unequivocal and a bit shocking. General Motors, judged by the composite answers, did not fall into the arms of either camp but marched bravely to a third position, stuck its banner in the ground and allowed us to see on it words emblazoned in letters of gold; we looked at one another, for those words didn't appear in the syllabus, the curriculum of either camp, and these words were thus strange to us. They were principally integrity, diligence and ability to express one's self. Humility was one, and one or two other qualities.

I do believe that the Professor from Toronto used the word "shocking" to heighten his meaning. We grew to know him quite well during the two weeks he was our guest. By his actions, he stood out to us as one who in his associations with students would definitely generate just the kinds of wholesome attitudes which industry desires, not only that the employee may make his contribution to industry but, more importantly, that he may make life satisfying for himself and for his family.

It is far more than my own personal opinion that we in business and industry have an obligation to share with the schools the responsibility of insuring that our young people are educated and trained for effective living in the world as it is, and not as some of us would like to have it. Our desire for favorable attitudes transcends any preference which we might have with respect to curricula, whether they be specialized or stress the basic sciences. It means that we think that all young people ought to be far more conscious than they are of the ultimate objective of all education and training, namely, becoming equipped to make a satisfactory living —but more importantly—to make a successful life.

Certainly, the college years are very impressionable ones for the future engineer. Professors and instructors have a superlative opportunity while indoctrinating their students in engineering knowledge to also instill the less easily defined fundamentals of effective living. In this latter task, the best teaching tool, to my mind, is the power of example.

Technical Societies

In this joint effort of ours, technical societies also have their opportunity to demonstrate to the young engineer the value of effective living as an engineer, for these societies offer a medium whereby the young engineer can obtain a broader viewpoint of his particular specialty. His society membership gives him the opportunity to hear the viewpoints of a broad cross section of engineers in his own field and to learn from their experiences.

I suggest here that technical societies make sure that their younger members have an opportunity to discuss with older members informally and quite frequently their areas of mutual interest. The society should do this as a primary "bread and butter" job; for it is quite easy for a young engineer to gain precisely the kind of technical information heard in lectures simply by visiting a good technical library. Any society also has the opportunity through its membership to disseminate information on the technique of effective living. And since it is a society, it also must offer some

social outlet to its membership. This enables the older members to set the same kind of good example which professors can set in the classroom.

Industry and the Individual

Just as the responsibilities of engineering education and industry intermingle, so do those of industry and the individual. As I've mentioned, engineering educators train and develop a young man to *become* an engineer and industry has the responsibility of creating a climate in which the graduate can express his training in work. His profession must not be permitted to lapse, as some might have it, into a simple *trade* wherein his productiveness would be measured purely by hours spent on the job (though this is necessary) rather than by his creativeness as a member of a proud profession.

Industry's responsibility is to create a good climate for creative engineering. We need to give due regard for the worth of an engineering education. We need to assure ourselves that the young engineer gets as profitable experience and training during his first years as does the medical school graduate during his internship. Further, we need to establish and maintain equitable policies and practices relating to salaries and promotions so that the young engineer will have the benefit of personal rewards commensurate with his ability to translate his engineering knowledge into work for the success, both for the business and for himself.

On-the-job training is necesary but industry would find little success in forcing its young graduates to continue in night school until they obtained advanced degrees. That step, too, is left to the individual initiative of the young engineer. He must *sense* the advantage of further formal education to equip him for making a greater contribution of himself to his company. From a practical standpoint, I cannot see how industry can arbitrarily set down practices which would guarantee progress purely on the grounds of employees obtaining advanced degrees.

The young engineer, too, has a grave responsibility in his first years. He needs to find his own definition of successful living and a way to derive the maximum benefit from both his technical education and his ability to work as a member of a team—to lean on his colleagues and to serve them at the same time. His attitude toward them and toward his work will determine his own success in developing his abilities to their elastic limit. In the final analysis, the young engineer himself has the responsibility for his own self-development.

Now we should warn the young engineer that while he might know what the ideal working and learning climate is, he will not find it exemplified perfectly anywhere—in any industry, in any college or university, nor in his association with any technical society. Human beings are seldom capable of perfection in anything. The young engineer then needs to adjust his own thinking to the situation as he finds it and to try to improve the situation and himself within the framework which he finds. One thing is certain, a wholesome attitude in each new engineer in any laboratory is a force to the good. One candle in the dark can shed its light a great distance; so the new engineer is capable of being a strong influence in creating the right kind of atmosphere in places where it did not exist before his arrival.

Conclusion

In summary, the entire program of helping make the engineer's first five years in industry successful is a joint effort. I want to emphasize, however, that in the final analysis engineering education, technical societies, and industry can serve only to assist the young engineer in his own development—to point the way. The sole responsibility for assuming and developing right atti-

tudes toward work, toward people, and toward living—and thus developing a successful life—rests squarely on the shoulders of the young engineer. No agency or other person can do the job for him.

The young engineer will find that hard work on his part is the key to his success not only in his five years but in all his years to follow—and gentlemen, there is something dignified about hard work. If he needs assistance and is looking for a helping hand, let him first be sure to use the two that are hanging at his side.

This, in a nut shell, is what "Experience Tells Me."

Sections and Branches

The Fall Meeting of the **Middle Atlantic Section** of ASEE was held at the University of Pennsylvania on December 5, 1953.

The morning session was held in the University Museum Auditorium, and was opened by Chairman C. F. Bonilla. He introduced Dean C. Chambers of the Moore School, who, in turn, had the privilege to present Dr. G. P. Harnwell, President of the University of Pennsylvania, who welcomed the members and their guests. The speaker for this meeting was Dr. M. D. Whitaker, President of Lehigh University, whose subject was "Our Changing Problems." These problems include crowding, curriculum content for broad cultural training, lack of teachers, which is most noticeable in the elementary educational group at present, but which will reach the high school and the college groups in the near future. A solution to some of these problems, even in part, would go far to improve our educational system.

A business meeting followed the morning meeting. After the approval of the minutes of the Spring Meeting held at the University of Delaware, and the financial report, Chairman Bonilla received the report from the Nominating Committee, and, since there were no nominations from the floor, moved that the following be declared elected:

Professor H. M. Jenkins, Swarthmore College, Chairman

Mr. Forrest E. Allen, The International Nickel Co., Inc., Vice-Chairman

Dean Thorndike Saville, New York University, Section Repr. on Council, and Professor H. S. Bueche, University of Delaware, Secretary-Treasurer, had previously been elected.

The Chairman requested the Section to vote on a new By-Law, namely: At the election of officers in even numbered years, the Nominating Committee present the name or names of those to be voted in as Section Representative on the National Council. This office is for two years, and the person elected takes office ten days after the Summer Annual Meeting following his election. This By-Law was approved.

The Chairman appointed a committee consisting of William Allan, *Chairman*, D. J. Stanley Morehouse, and A. W. Luce, to study the Grinter Report. Since so many present had not seen or even heard of this report, it is hoped that a broad informative report may be made at the Lafayette College meeting.

The Section also approved prize awards for the winning papers in the Paper Contest for Young Engineering Teachers. These awards for 1954 will be $25.00, $15.00, and $10.00, and the papers will be eligible for the National Prizes of $200.00 and $100.00.

Seven group meetings were held in the afternoon, followed by a social hour at the Penn Sheraton Hotel. Dinner for over 150 was held in the same hotel, after which there was adjournment.

Summer Employment—Boeing Style

By HAROLD P. SKAMSER

Chairman of Engineering Placement, Michigan State College

and CLYDE E. WORK

Associate Professor of Mechanics, Rensselaer Polytechnic Institute

A lively interest seems to be developing in organized industrial employment of engineering faculty during the summer. This offers one promising answer to the need for closer cooperation between these two groups to cope with the complexities developing in modern industry and to facilitate the application of advances in science and technology in college and industry.

That employment of faculty members in industry is already widespread was indicated in a survey conducted last year by the Relations with Industry Division of the ASEE. Faculty members reported experience in industry on the following bases:

1. full time (previous to teaching)
2. part time (while teaching)
3. consulting
4. leave of absence
5. summer

A broad field of activities were included in the industrial groups listed as employers.

This article has been prepared to point out the considerable opportunities which summer employment of engineering faculty members offers especially to engineering education. Some of these advantages can be gained in other ways, some cannot. The inspiration for writing this article resulted from a summer spent by the authors in the Summer Faculty Program of the Boeing Airplane Company in Seattle.[1] The Boeing program and comments on it will be used as examples here,[2] because Boeing has combined the advantages of hiring faculty consultants and sporadic employment with those of "Seminar" summer indoctrination programs, so popular in the East.

Full Time Industrial Experience

Experience in industry on a regular full time basis previous to teaching or at intervals during the teaching career sounds highly worthwhile, but if considered alone has considerable practical limitations. If undertaken immediately after college the professional level of such experience is not likely to be high enough during the first few years to make an optimum contribution to later teaching. Impressions resulting are from a limited period in this type of job in only one company and would not be sufficiently broad. If the engineer progressed rapidly or worked long enough in the industry to attain a position of responsibility with experiences and a perspective of real value in teaching, the remuneration he would receive in industry reduces the chances of his being attracted to teaching.

[1] Professor Work was a Summer Faculty employee and Professor Skamser was the Coordinator for Boeing's (Seattle) Program in 1953.

[2] A second article will appear in next month's *Journal* describing some of the features in Faculty Employment Programs, Teachers' conferences and Seminars developed by other companies.

If his full time practical service should have been prior to his teaching career, the continuous advances in technology and commercial practices gradually reduce the applicability of early experiences to current and future situations. To repeat periodically, such service on a full time basis to keep up to date and to cover several areas of interest requires breaking continuity and is rather difficult to work out.

Part Time Employment

Part time practical work outside the teaching profession is limited to those geographically situated so as to be convenient to the industrial groups with which the professor is to work, to men in schools where policy permits and where private employers have part time assignments. This always represents a conflict of serving two masters. Usually the balance is too delicate to maintain and the interests of one are allowed to encroach on those of the other.

Consulting

Consulting work during vacations and other free time provides variety of experience of timely interest and application. However, these positions are not generally available to the ones who need the experience most, the young and inexperienced teachers. Experience limited to consulting tends to provide a somewhat distorted picture. To be called in as an expert in a particular phase of work to tell others what they did wrong or tell them how they might try to handle a problem is a far cry from the real situation of meeting daily problems and living with the situations which you develop.

Leaves of Absence

Leaves of absence cause enough breaks in the continuity of an academic program and for perhaps other reasons they are rare enough to offer only very limited help in this area and when given are less frequently available to junior members of the faculty.

Summer Opportunities

Examined in the same light, summer employment offers real promise:

1. It is available at all academic levels and for members of faculties of all schools.
2. It can be repeated periodically to give a broad perspective of different assignments, of different industries, different geographical areas, and up-to-date ideas brought back to the classroom.
3. It provides a real change from academic routine and responsibilities without interfering with continuity of scholastic programs.
4. The level of professional experience advances as the professor himself develops.

How much is gained from summer experience is determined by the positions available, the assignments given, the attitude of the professor and the attitude of the employer.

The Summer Job

The most common form of summer employment of faculty by industry involves hiring a specific man to work in a particular division of the industrial group on a specific job assignment during the period of his summer vacation. With the current need for engineering services there are large quantities and varieties of opportunities available on this basis. Even if the employer makes no effort to expose the temporary employee to more of the companies operations and problems than the specific job to which he is assigned, the professor can make a definite contribution to his employer and his summer's activities and contacts can contribute toward improving the effectiveness of his teaching.

The Industrial Conference

Another type of summer opportunity for college teachers offered by industrial groups is in the form of a conference or seminar program to which a group of educators are invited. An enlightening program of lectures, discussions and tours is presented at company expense to give those in academic positions a comprehensive picture of a rather broad scope of the activities, facilities, philosophy and problems of the host company. In the extreme form little if any return is expected of the educator beyond goodwill and his voluntary criticisms and suggestions.

The Boeing Plan

The program which has been developing at Boeing combines the advantages of both limiting cases. Participants are impressed by the evident sincerity and energy of those responsible, who continually revise the program to make it increasingly worth-while from the educators standpoint, while maintaining the productivity of summer employees to pay the bill.

Objectives: (1) *To accomplish significant work assignments.* With their large background of engineering commitments many items lend themselves to assignments of two or three months duration. Selection of summer faculty employees, is based primarily on the work assignments available each year. These extra man-hours are particularly timely in equalizing the work load when many permanent employees are on vacation.

(2) *To provide industrial experience for professors.*

Because of its nature, the aviation industry must be operated in a different manner from most other industries, extremely flexible, quickly adaptable to new ideas and constantly pioneering into the future. Because this industry is destined to continue as a major factor in industrial, economic and military future of our nation, it is important that professional teaching personnel be familiar with some of these concepts by direct association.

(3) *To provide mutually beneficial relationships with technical schools.* New engineering manpower for Boeing must, for the most part be obtained from the graduating classes of accredited technical colleges and universities. It is believed that training of this potential manpower can be greatly enhanced by the association of students with teachers who themselves have had direct contact with the Boeing organization.

Details of Program: From 50 to 75 full time faculty members, purposely selected to represent as many schools as possible (distributed geographically over the whole nation), are offered assignments for a minimum period of two months in the various units of the company's organization. Note: 72% of the 1953 group were under 41 years of age. 30% were instructors and assistant professors.

In 1953 the professors worked in the following areas: gas turbines, process units, metallurgy lab, personnel, salary administration, aerodynamics, stress, structural development, power plant, liaison, and electrical work for the C-97 stratocruiser, the B-52 heavy bomber projects, mechanical equipment, air systems, hydraulics, servo-mechanisms, acoustics, electronics, armament, physical research, Bomarc (guided missile) etc.

In order to cover as large a number of different faculty members as possible only a few repeaters are selected and then only when it appears particularly worth-while to continue a given project into a second summer.

Each summer-hire professor participates in the one day indoctrination program for regular new engineering employees to begin his familiarization with the company and to let him see, first hand, how permanent employees are indoctrinated. Those faculty members who are assigned to Project Groups, and require more familiarity with company standards and procedures of design and pro-

duction, participate in the regular two-week familiarization course before going to their assignments.

Seminars: One hour weekly is devoted to seminar meetings for summer faculty members and certain key Boeing personnel with the purpose of acquainting each faculty member with the broader aspects of the company.

Each summer the nature of the seminar programs has been varied to suit the interests of the visiting faculty members. However the first three programs each summer generally give a broad over-all picture of the company. The first is a general discussion of the company by a leader such as the Senior Vice-President. The second seminar is concerned with the manufacturing organization led by a top executive in Production Engineering. The third treats the Engineering Organization and is presented by the Chief Engineer.

Other seminar programs were planned and topics are selected by the participants themselves who, in 1953, chose subjects such as: the jet transport, guided missiles, analog computers and industry's evaluation of technical education.

Plant Tours: The more or less formalized tours of the Boeing facilities have evolved through the years into a plan for four half-day tours in 1953, each devoted to one of the four major areas. Guides and those planning the tours were exceptionally receptive to the desires of the participants and additional tours of areas of special interest were arranged upon request. Visiting professors are encouraged to visit any other areas of personal interest.

Faculty Coordinator: One feature made possible in as large a program as this was the selection of an engineering school placement officer for the job of direct leadership in the activities of the summer-hire professors. His duties were (a) to assist in detailed planning of the lectures and seminars, (b) to act as liaison between summer participants and the company and to assist in ensuring suitable technical assignments for all participants, (c) to assist in the detailed planning of such recreational activities as are developed, (d) to act as advisor in matters pertaining to "off the job" counsel and assistance and (e) surveying the faculty to assist in evaluating the program, etc.

Social and Group Activities: The summer faculty planning committee with the leadership of the coordinator arranged two major social functions, a family picnic and a chartered boat trip around the Seattle harbor and canals. The coordinator also represented the group, in planning with company officials the welcoming buffet supper, an afternoon program for wives, and a farewell dinner. The stimulation of warm personal friendships with other visitors through informal social and work orientation activities proves to be an extra feature of the summer.

A visit and tour of the University of Washington Engineering School was arranged with the cooperation of U. of W. faculty participants in the summer program. Visiting professors also became personally acquainted with the personnel in the units in which they worked and were invited to share their social activities during the summer. They were also given Honorary Supervisors Club cards.

Talks with Alumni: The summer offers opportunities for comparing notes on education and industry with former students, currently employed at Boeing. Through the coordinator's efforts, a directory of their alumni (employed by Boeing) was made available to the summer faculty group.

Housing: To take advantage of the superb geographical attractions of the area for combining vacation with work, the summer at Boeing is a family affair and participants are aided in arranging suitable quarters for the summer by the company housing division.

Compensation: Salary during the period at Boeing is based on the applicant's current teaching salary as computed on

a nine months basis. An allowance for travel from his place of residence to Seattle is also offered.

Conclusions

The outstanding success of the Boeing summer faculty program depends primarily on a mutual feeling of accomplishment. The short term results of the program to the company are very gratifying. Supervisors reports have indicated unquestionably that the program is an economic success—that the actual engineering work accomplished by faculty members had fully justified the cost of the program, exclusive of the intangible benefits. Faculty members, almost without exception, are enthusiastic in their belief that this type of program is superior to casual summer employment which they had previously experienced. In a winter survey, 93 per cent of the 1953 group indicated that their experience made a significant contribution to their teaching through practical illustrations, better understanding of the industrial position, broadening of viewpoint etc.

Justification for the Boeing Program and similar efforts in other companies can be summarized by the statement of one Boeing summer-hire professor, "No engineering professor can do a satisfactory job preparing students for their future work, unless his own experience has been periodically revitalized by working contact with industry."

College Notes

In response to a growing demand for increased part-time engineering training, Dr. John R. Dunning, dean of the **Columbia University** School of Engineering, has announced that a full undergraduate course of study leading to a B.S. degree in industrial and management engineering will be given at night, starting with the 1954–55 academic year. While the School of Engineering has been offering graduate work at night for several years, the industrial and management engineering curriculum is the first such program to be offered on an undergraduate level.

The annual **Cornell Summer Laboratory Course** in Techniques and Applications of the Electron Microscope will be given this summer from June 14 to June 26, 1954, by our Laboratory of Electron Microscopy in the Department of Engineering Physics. The course under the direction of Dr. Benjamin M. Siegel will have Dr. James Hillier of Melpar, Ind., Alexandria, Virginia, and Dr. C. E. Hall of M.I.T., Cambridge, Massachusetts, as guest lecturers this year.

The course is designed for those research workers, institutional and industrial, who have recently entered the field of electron microscopy or who are now planning to undertake research problems involving applications of this instrument. Further inquiries should be addressed to Dr. Benjamin M. Siegel, Department of Engineering Physics, Rockefeller Hall, Cornell University, Ithaca, New York.

General Observations on Cooperative Education*

A. At Aluminum Company of America, Alcoa, Tennesse

By JAMES W. HOYT, JR., *Works Personnel Manager*

Many of our top management executives, engineers and supervisors are products of the cooperative plan, an educational program under which college students alternate periods in school with periods in industry to get practical experience along the line they are studying. We have been using the co-op system at Alcoa since 1926 and the quality of personnel secured through this program has been very gratifying.

We all agree that it is necessary for engineers, and other professional people as well, to have practical experience after graduation before becoming proficient in their field. We consider an engineer who has co-oped with us to be at least two years ahead of the engineering graduate. Some of our junior executives who were among the first to come with us via the cooperative method, feel they acquired far more than two years' experience.

Before detailing the actual procedures of handling our cooperative program, I believe we should ascertain first the great difference that confronts a technical graduate of today, and some fifteen years ago. In bygone years a brilliant technical man could enter into industry and become quite successful because his ideas could be applied without question. Today that man is handicapped if he has not acquired executive and administrative abilities in the field of industrial relations. In our present modern setup, where labor unions have acquired great strength and overall changes have taken place in our concept of relationships with all groups, the chief engineer is required to use more and more human engineering along with his technical engineering ability in directing his department. His success depends to a large extent in getting along with people at all the various levels, from the operator of a machine to the works manager.

Now let us turn to our cooperative program as it works in our Alcoa plants. It has been our policy and practice to rotate each co-op student in various types of work, giving him training in all phases ef engineering and operating work. This method enables him to find out how these various departments function and how each is dependent upon the other, how they all, working together, form a team. Co-op students gain practical knowledge of our operations, and above all, they get the thinking, attitudes, etc., from the hourly workman as a co-worker that they can never acquire when they come into an industry as a graduate engineer working on the engineering staff or as a technical trainee in an operating department.

Rightfully or wrongfully, there is a stigma placed on any graduate who has never worked with hourly people when he comes in over them. I do not mean to intimate that all egnineering graduates who have not co-oped are doomed. I am merely accenting that a co-op has a distinct advantage in this field. There is a great deal of difference in the environment of a college campus

*Presented to the Cooperative Education Division of the American Society for Engineering Education, Gainesville, Florida, June 24, 1953.

and that found in most industries. The universities stress intellectual attainments and the problems are somewhat limited in scope. In industries, on the other hand, there is pressure, tension and demands for results. The cooperative method will tend to acquaint the student with the many problems that will confront him in later life in the engineering field.

We purposely assign co-op students to various types of work to find out how they will react under certain tasks and conditions. By this method we are able to judge the attitude, mental and physical make-up of the co-op. We collect the recommendations from the various departments in which a co-op works, and from these we make the final appraisal of him.

Upon checking records of our co-op students, who trained their entire period with us, only five are not with us today. Two of these are in the armed forces. Yes we are proud of this record and rightfully feel that we should be. It is our firm conviction that the Aluminum Company of America's policy is sound and that our relationships are fair and equitable. Therefore, when a co-op works with us through three or four years in the program we feel that he will want to come to Alcoa.

Another important phase from the Company's viewpoint in the cooperative program, is to take sufficient time to orient him into the organization. Usually this is the first time he has been away from home. He is among strangers and required to plan and make decisions with which he has never before been confronted. He must have a feeling of "belonging" and be made to realize he is part of the organization, whether it be large or small.

You who are university coordinators play a far greater part than the companies in the success of the cooperative program. You must be an adviser and counselor to these co-ops because they no doubt have many problems other than their studies with which they turn to you. In my opinion, industry in general should do more to fulfill its share of responsibility in making the cooperative program successful. We are hopeful that we have not been neglectful of our responsibility in the Tennessee Operations. I believe we have made a sincere and honest effort to carry the full responsibility which should be our just burden.

There are advantages to the co-op other than the means of obtaining an education, which he could not otherwise obtain because of monetary reasons. Every engineering student must at some time or another determine for himself whether or not he belongs in the engineering field. We have from time to time found boys who think they want to be engineers, but after a few quarters of school work and work periods, decide they do not like the engineering field. I remember one young man who co-oped with us for two years to find he was not interested in his selected engineering field. He told me he had wrestled with the decision for two quarters trying to make up his mind to change from engineering to the ministry. He had become interested in church work and found it more appealing than engineering. I knew he had another interest because his heart was not in his work. After telling me his story, I frankly advised him to change his course and give up his co-op work. Today this fine young man has been ordained and is making a success as a minister.

The co-op in turn has an opportunity to judge, appraise and pass final decision upon whether he would like to work for that industry. Furthermore, it gives him an opportunity to decide if the particular field he is studying in is the one in which he would like to cast his lot for life's endeavor. It has been our experience that several students through the cooperative program have decided to change their course of study and many of them have become success-

ful in other walks of life rather than working in industry.

At our Tennessee Operations in Alcoa, we instigated a new phase of the co-operative program, at least it is a new phase with us. No doubt other industries may have already entered into this field. This specific phase was to contact the various high school principals in the surrounding area to encourage their more likely students to enter into the co-op program. In our general personnel contacts we visit twelve or fifteen high schools in the spring of each year, so actually it was little trouble for us to enter this phase of cooperative solicitation, so to speak, along with our normal visits. Another method we use is to present to our Management Conference Program, which has an attendance of about four hundred twenty-five people, the co-operative program pointing out its advantages to people who probably otherwise could not or would not receive a university degree. These conferees in turn were encouraged to express the possibilities of the cooperative program in their communities and localities. We feel that in a few years this will bring beneficial results to industries and universities who are interested in the cooperative program. I would like to point out that in our visits to high schools, we would never acquiesce to employing any student where there is a possibility of his seeking higher education.

We at Alcoa realize that the cooperative method has come a long way since its inception. We fell it is better today than ever before. In other words, gentlemen, we like it and plan to continue the program at Alcoa, Tennessee.

B. At E. I. du Pont de Nemours & Company, Chattanooga Tennessee

By D. G. MACDONALD, *Personnel Supervisor*

Many of the citizens of the world are educated by experience only; others are well-trained in the theory. Co-op graduates have both. Perhaps my boss had a reason when co-ops were first talked of when he said "Can you prove that the program is worth the cost and trouble?" The last hurdle was cleared when we were able to establish jobs that were outside of the bargaining group of the union. The start of the program was slow and intentionally that way. This allowed us to work with co-op directors and design a work program that would accomplish our primary objective—to give the co-op graduate the best possible training for long-range responsibility in industry —we hope our own.

In our business we often find ourselves trying to establish objectives and working out a sound philosophy for doing a job. Our co-op program objectives have crystallized as follows:

1. Graduate Procurement
2. Improved Training
3. Vocational Guidance Assistance
4. Shorten Final Orientation Period.
5. Help Students obtain Education
6. School Relations.

On a Cooperative Student's first day at work, our Training Supervisor spends a lot of time showing the man around and introducing him to the Manager and his staff members. We help him find a place to live and give him a special booklet of hints that will help him feel at home and find his way around the plant and the community. For the first week the new co-op follows a schedule that will carry him to all areas of the plant and he is introduced and talks with many members

of supervision. He is never left alone during this first week.

In our plant, co-op engineers are placed in one of the following jobs depending on their course and expressed interest:

Works Engineering
Methods and Standards
Process and Development
Production

Our whole program is built on the premise of varying the work experience to broaden the student's knowledge and understanding. This can be illustrated by the schedule of a civil or mechanical co-op in our Works Engineering Section as follows:

Assignment	Work Period
Design	1
Maintenance	2
Project Construction	3
Power	4
Design +	5
Design + +	6
Design + + +	7
Design + + + +	8

In the above schedule the trainee is assign problems and work of an increasing complexity, and by work period No. 5 he will begin to develop experience and real productivity. If not capable of handling a job alone, he will work with an experienced engineer until experience develops. We endeavor to extend the individual's capacity and give responsibilities commensurate with ability.

The co-op is always responsible to one man only. This individual supervises his work and talks with him about his performance, and at the end of the quarter, makes a formal report for management and the college.

We, at the Chattanooga Nylon Plant, are enthusiastic over our co-ops.

Our Company follows a practice of financially recognizing the five-year co-op over the four-year B.S. All during the co-op work experience we also grant a $15 per month increase each work quarter.

We rely heavily on the assistance and cooperation of the college co-op coordinators. Their help is indispensable and we have evidence that the joint effort has been effective in correcting faults and weaknesses in individual cases. In my job no greater satisfaction can be realized than observing successful personnel development.

The Place of Advanced Degree Engineers in Industry*

By S. L. SCOTT

Personnel Division, E. I. du Pont de Nemours & Co.

No one who has been concerned with the recruitment and placement of technical graduates during the past year can be unaware of the current high, unprecedented demand for engineers of all levels of training, and certainly demand implies need. It does not follow necessarily, however, that this recognized demand and its implicit need signify a proportional—or higher—increase in the requirements for men with advanced training. Yet the last decade has shown an unmistakable trend toward increased utilization of engineers with graduate training. Although graduate work in engineering has not gained the status that has come to be accepted, for example, in chemistry, a glance at the numbers of degrees granted during selected years since 1938 provides ample evidence of its growth.

	1938–39	1939–40	1942–43	1946–47	1948–49	1950–51
Number of first degrees	12,408	11,358	14,145	18,592	41,793	41,893
M.S. and other predoctoral degrees	1,219	1,318	637	3,090	4,783	5,134
Doctor's degrees	97	108	87	127	417	586

Obviously there must have been some incentive for the attainment of this additional education. Granted that the G. I. Bill made it possible for greater numbers to attend college and to continue beyond the baccalaureate degree (in all disciplines; engineeering was not unique in this respect); granted that the schools themselves have tended to require that their staffs possess advanced degrees; and granted that our continuously expanding economy has provided employment for ever-increasing numbers of technically-trained men—even so, these opportunities would not suffice to stimulate graduate work to the extent that it has flourished. Furthermore, the number of individuals who seek advanced degrees for the degrees' own sake must be negligible; present-day economics do not foster the luxury of education for which there is no market.

No attempt will be made here to set forth all of the reasons for advanced work, but it cannot be denied that personal satisfaction must stand high on the list. The desire for knowledge is compelling to certain individuals, and intellectual curiosity is undeniably a prime requisite for success in any technical pursuit. Those so endowed are usually the ones who seek or are urged to attain the higher levels of training. The significance of this motivation must be all the more readily apparent today, when the availability of jobs furnishes such strong temptations to terminate education at all transition points.

Economic Advantages

To argue that higher financial reward is the sole and sufficient goal of addi-

* In this study, the author was assisted by B. R. Teare, L. R. Baker, Robert F. Moore, and T. K. Sherwood.

tional training is to ignore other, equally or perhaps more important, factors. On a purely practical basis, the economic advantages of a master's or doctor's degree are difficult to substantiate. Certainly engineers with advanced degrees *should* command higher starting salaries than their B.S. associates, and the fact that industry, government, and the universities have established differential rates provides further evidence of the need for graduate training. The opinion that doctors are hired for jobs which could be done as satisfactorily by bachelor or master engineers is not uncommon, especially in academic circles, and may have some justification, but the laboratory director who maintains that long experience has demonstrated (to him) that the doctor will do the job better is probably quite right. He, and hence industry in general, feels very strongly on this point, else he would not be willing to pay a premium for talent if he could hire its equivalent at a lower salary. No private organization can afford such extravagance in the face of today's competition.

Certainly it behooves any employer to make the most efficient use of his investments, whether they be machines, men, or money. Of these, the most critical are the men, and no one is harmed more than the man whose abilities are not challenged to the utmost. Industry has often been accused of diverting its advanced degree engineers into channels which do not utilize their specialized knowledges and techniques to their fullest capacity. Such accusations are not always groundless. But it should not be forgotten that people's interests change, that circumstances are never stagnant, and that it is not always easy to judge whether someone else is contributing his maximum productivity.

Monetary reward is probably "after the fact" as evidence of need for the advanced degree engineer in industry. The real reason is much more basic: growth of opportunity for his services. This opportunity lies in industry and government as well as in teaching, and mostly in industry, even though openings in government-sponsored installations have increased markedly since 1940. This is a natural partner of the growth of science and technology. Today any layman can cite any number of developments exemplifying that growth. It is indeed unfortunate that those which may be foremost in his mind may be associated with military objectives, and probably equally unfortunate that for every one of these there are many others—equally significant, and lacking the stigma of destructiveness—of which he is blissfully ignorant, but even that same layman cannot be unaware of the burgeoning complexity of technology.

For many years, fundamental research was regarded as the exclusive province of the colleges and universities (at least in this country). Perhaps it still should be. Certainly there can be no doubt that our academic institutions must continue to be our main source of basic truth and knowledge and that they must be encouraged in that respect to the utmost of our resources. But World War I demonstrated all too clearly the dependence of American industry upon European scientific achievement. Some forward-looking organizations were already aware of the value of research, of course, but the shortage of aspirin and dyestuffs—to pick two homely examples—was a very convincing argument.

Solidly Entrenched

Later economic developments have undoubtedly encouraged the trend. In any event, research appears to have become solidly entrenched as a proper activity of industry. Once established, its advantages were undeniable, and it flourished mightily. The more basic the industry, the more important it became, until today research is regarded as indispensable to survival, let alone progress. So intense has competition grown. The fact that government has entered the scene in a

wholesale manner does not alter the situation; it intensifies it.

If research in applied science is now an integral part of industrial endeavor, it is inevitable that more intense specialization in engineering lines should follow. For no matter how devoid of material gain a commercial organization may state the aims of its research to be, it is, and must be, in business to make a profit on its operations. No matter how long-range, or how theoretical, its scientific investigations, they must be paid for out of the earnings of that portion of research which resulted in a commodity which somebody wanted or needed.

The route between new knowledge in the laboratory and a new product on a retailer's shelf may be short and direct or it may be long and devious, but invariably the engineer's skill is required. The more basic the knowledge, ordinarily, the longer the route and the more the skill that is necessary. New products demand new techniques, new procedures, new materials in which to manufacture them, new designs—new everything, in many cases. And once a product is an article of commerce the factors of continual improvement appear. A procedure has to be "frozen" and standardized at some stage, but scientific and engineering research must go on. Obsolescence is inevitable. Even "old" products require constant surveillance; alternate routes, depletion of natural resources, further research, and a host of other reasons may start the cycle all over again.

The natural consequence of this situation (perhaps "snowball effect" is a more descriptive term) is increased emphasis on the more advanced and technical phases of engineering—the phases which have come to be known as design, development, and research. It will seem trite to say that the place in industry for engineers with advanced degrees is in these very phases, particularly during the early stages of their careers. The conclusion is too obvious, even though it is generally conceded that engineers seek training beyond the baccalaureate level in order that they may satisfy a desire to participate in those phases. But the conclusion is none the less true.

Questionnaires

Lest this might appear too arbitrary a deduction, two questionnaires were prepared. The first was submitted to those institutions whose engineering curricula are accredited by ECPD; the second was sent to a number of industrial organizations whose products or services were deemed to require a high level of engineering skill. Generally speaking, the replies to these questionnaires supported the above conclusion.

For example, the concensus of 91 replies from the 115 schools to which the questionnaire was sent was that there was an increased demand in industry for advanced degrees, and that individuals holding these degrees generally go into research, development, and design, in that order. Those institutions which grant Doctors degrees indicated overwhelmingly that the Doctor is more sought after than the Bachelor as far as the greatest number of desirable job offers is concerned.

The Employers' Questionnaire was submitted to a wide variety of organizations: aircraft, air lines, automotive, electrical, heavy equipment and machinery, petroleum, pharmaceutical, railroads, and a few which are popularly called "engineering" firms. Of 133 companies solicited for information, 112 replied.

Marked gains in the employment of advanced degree engineers were reported by the 57 companies which were able to provide data for 1940 and 1952. During that 12-year period, B.S. employment increased 147%; M.S. 208%; Ph.D. 175%. These gains are even more striking if the data are limited to those organizations employing (in 1952) more than 10 Ph.D.s; the increases were then 152% for B.S. degree holders, 219% for M.S. men, and 222% for Ph.D.s.

That the companies which hire the advanced degree men have found the practice rewarding is demonstrated by the fact that 65% of them indicated that their current trend is to hire proportionately more M.S. and Ph.D. engineers than B.S. men.

The data on how advanced degree engineers are used are especially interesting:

	Initially	After 5–10 years
	(% of replies)	
Administration	2.8	20.5
Design	22.0	15.7
Development	25.2	17.7
Production	15.1	12.2
Research	24.8	19.7
Sales	6.0	9.1
Other (unspecified)	4.1	5.1

These figures indicate that the great majority of the advanced degree people remain in the more highly technical types of work. Interestingly enough, 80% of the replies stated that these men do *not* have a better chance of getting into administrative work than the Bachelor—with the possible exception of *research* administration.

Remarkable Parallelism

Both questionnaires requested general observations of the place in industry of engineers with advanced degrees and of the trend of their industrial employment, and there was a remarkable parallelism between the replies from the companies and those from the schools. Research and development were invariably mentioned as the proper niches for engineers with advanced degrees, with design a strong third. It is significant that production, which ranked fourth on a statistical basis, was rarely mentioned in the comments as an opportunity for the individual with graduate training. This may be due to an idiosyncrasy of classification: technical employees in plants are often listed as production workers—for budget purposes, if for no other reason—even though they are actually engaged in activities which under any other circumstances would be designated as development. This practice is not universal, of course, but it is nevertheless widespread.

With respect to the trend, the concensus was that the need for advanced training is on the increase. Even organizations which do not hire such individuals thought that to be the case. One comment in particular appears to summarize the situation: "With the rapid advance and progress of science, it is becoming increasingly difficult to do more than scratch the surface in most engineering fields in the normal 4- or 5-year engineering curriculum. Advanced work is, therefore, becoming necessary and even mandatory, especially in research and development."

The author wishes to acknowledge the assistance of L. R. Baker, Robert F. Moore and T. K. Sherwood in the preparation of the questionnaires mentioned above and in approving the final report.

Grease Monkeys or Citizens?*

By DR. EDWIN S. BURDELL

President, The Cooper Union, New York, N. Y.

I have long wanted to pay tribute to the teachers and administrators who have contributed to the development of the technical institute. Having been engaged in professional education of one kind or another since about 1928, I would venture express the opinion that the technical institute is the largest single innovation in our American educational system in the last twenty-five years. The great development of American high schools, which began another quarter of a century earlier, has had a tremendous impact on American culture, but at the post-high school level the technical institute as part of the junior college movement has been most intriguing to me and, while I have been only on the outer fringes of it, I have watched it with great interest. I was fortunate enough to have served on several committees of SPEE with Harry Hammond, while he was Dean of the Engineering School at Penn State. I served on the commissions that produced the 1940 and the 1944 reports. As you know, in the 1944 report there was a section devoted to the importance of the technical institute. That evolved from many thoughtful discussions by the members of that commission. We all felt that Dean Hammond was doing a great service to American engineering and industry by bringing the technical institutes into the fold, and we wanted to get behind him to support him.

Lack of accreditation up to 1946 was somewhat of a handicap in securing government grants during the war years, but that is all behind you now. The twenty-two of your sixty-four institutions that are now under the wing of the same accrediting council that certifies the engineering schools deserve congratulations. There are many limitations to accreditation and there are a lot of people who are setting up quite a fuss about it. Perhaps it has gone too far. Certainly, in the great state universities where there are seventy-five to a hundred separate agencies coming in, accreditation has reached burdensome proportions. But the educational principle of having some annual or biennial evaluation by an independent group of professional people is a matter that no college faculty should resent. It is very easy to get annoyed at filling out forms and bored at entertaining "visiting firemen" who come to inspect what you are doing, but taking serious objections to it is a short-sighted point of view for professional people. We need to have a mirror held up to ourselves occasionally and the fact that the technical institute existed for many years without any such self-evaluation does not justify that it should hold out against a general trend in American education.

Impact of Technological Advances

I would like to turn now to something that is probably as obvious to you as to me: the inevitability of the development of the technical institute due to the impact of the technological advances brought about by World War II. I have never ceased to be amazed at the fact that great constructive advances of mankind seem to be so closely associated with the de-

*An Address at the Annual Dinner of the Technical Institutes Division of the ASEE, Gainesville, Florida, June 23, 1953.

structive activities of man. Certainly science, the medical arts, and industry have gone ahead by leaps and bounds through the impact of war. So, however much I as a sociologist and as a humanist deplore it, I have to recognize the paradox and give the devil his due. For instance, the enormous training program that was necessary to operate the mechanisms associated with the mechanical end of flying required 2,000,000 skilled and semi-skilled technicians. Not only in war production, but in postwar production, the replacement of the individual craftsman by automatic machinery, automation, and servomechanisms has required a whole new category of the non-professional personnel to operate them.

Associated with this impact of postwar development is the scarcity of professional engineers and I would like to say a word or two about that. We are engaged in the production of engineering talent at The Cooper Union, where we are terribly concerned about the loss of teachers to industry. It's a good deal like the Biblical warning about not "eating the seed corn." How in the world can industry expect to have properly educated and trained professional people if industry persists in hiring away our teachers? I am glad to see that some industries are beginning to be concerned about it. The practice even affects our undergraduates. The seniors who have the prospect of choosing from among a dozen jobs at $350 or $400 a month let down their efforts in their senior year. Why worry? A sheepskin from old Siwash is all that's necessary. It even affects the junior year students who see their seniors flying off to weekends on the golf links in North Carolina—with, of course, the stated objective being the inspection of a cotton or dyestuff plant somewhere in the Tennessee Valley. The entertainment features, the disturbing factors of many industrial recruitment officers on the campus, have had a demoralizing impact on engineering education in the last few years. Now, I don't want to be misunderstood and say that I object to having our students being offered many jobs at good salaries, but you know perfectly well they aren't worth $400 a month and we know they aren't worth it, and if this delightful balloon on which we are riding happens to deflate, there are going to be some pretty dissatisfied and frustrated young men.

Low Utilization of Engineering Talent

I think also that industry hasn't been fair when it has stockpiled a good deal of the engineering talent that we do produce. There is a low utilization of engineering talent. We are told by some of our young graduates that they sit around and simply mark time. I made such a comment to the personnel directors in Pittsburgh some time ago and instead of being denounced there was a good deal of pointing accusing fingers not, of course, at themselves but at the fellow in the next seat whose company was stockpiling engineering talent waiting for that pot of gold at the end of the rainbow—that aviation contract that *might* come when they *might* need fifty engineers when actually they could get along with twenty-five. I understand also that it has caused a good deal of dissatisfaction among the older men who find themselves in competition with these youngsters and, with more or less fixed salary limits, it means that they have to go to job-jumping in order to gain salary increases.

All of this comes back to the fact that we need to produce more technical institute graduates. We need to produce more engineers, of course, but this is a group interested in technical institute education and training.

Thus, from a philosophical as well as a practical standpoint, you are greatly needed. The well-publicized shortage of professional engineers makes a tremendous demand on you people to increase your output. There is a recognized need for the "in-between" group—between the craftsman who will never go beyond using his hands, however skillfully, and the man

with the intellectual capacity to design and do other professional work. So you have a groove of very precise dimensions. I've talked to Director Klitgord and his associates over at the New York City Community College of Applied Arts and Sciences and I know that they are very conscientious not to take on youngsters or keep youngsters who are equipped mentally for professional engineering careers. The Cooper Union, being free-tuition, is the logical place for him to send some of those men. On the other hand, we have two to three thousand applicants each year and the vast number of those are not equipped for professional education. We return the compliment by suggesting a technical institute for some of those. As to numbers, for the last year that I have figures, the technical institutes graduated only about eighty-six hundred students from technical courses during the same year when forty-two thousand engineers were graduated. What a complete reversal of what the situation should be! If you take the modest ratio of three to one, the technical institutes should have graduated in that same year a hundred and twenty thousand instead of eighty-six hundred.

Broader Objectives

I would now like to come to the crux of my paper and to assert that in my opinion there is a need for acceptance of broader objectives of technical institute training. Present-day living requires preparation for life as well as for earning a living. To be sure, that sounds pretty trite, but that is the title of my paper —"Grease Monkeys or Citizens?" You have to raise your sights. The demands of modern society indicate that you must. There must be a motivation for participation in our democratic society and it is just as much an obligation on the parts of the educators and the technical institutes to take that on as it is to train them in the technology of the particular specialty. You simply can't take for granted today that our young citizens are going to find their way around in human relations in the shop, in the community, and the home; that they are going to be familiar with the helpful modern concepts of family life; or in citizenship matters that they are going to make intelligent choices of candidates for office; that they can exercise good judgment in accepting or rejecting proposals for community improvements especially in matters of public schools or in matters affecting our fundamental political organization, constitutional changes, and so on. Nor can you be sure that they can discriminate between good or bad leadership in their trade unions and in their social organizations; or be able to cope with situations that involve racial and religious difficulties. I'm sure that you will agree that there are areas of tension in American communities that are definitely slowing up industry and the good society because people are not familiar with present-day methods of coping with some of these racial and religious difficulties.

In other words, we must develop in these young men, whether or not they are of sub-professional level or professional level, a sustaining interest in the common welfare and in the cultural aspects of community life. There are no class distinctions in the matter of the enjoyment of the good life. There is no reason why the man in the three or four thousand dollars a year bracket should not be entitled to enjoy and benefit by the knowledge of good music, of artistic expression, and the development of his personality through adult education programs. He is just as much entitled and perhaps has just as much to contribute as the chap who is at a professional level. And I'd like to again interject my institution and its background by quoting from Peter Cooper, a remarkable man, who had tremendous insight for an industrialist in the mid-nineteenth century. In our Deed of Trust he provides: "that courses of instruction on social and political science, hereinafter provided for, shall have the preference over all the

other objects of expenditure specified herein, in case there shall not be means adequate for them all, and shall forever stand pre-eminent among them."

What was Peter Cooper saying? He was saying that his institution was not to turn out grease monkeys. He was saying that it was going to turn out citizens —people who, above all, had a background in social science, politics, and science and, therefore, would have a better understanding of the conflicts that were growing in the mid-nineteenth century on the eastern seaboard of America. And he went further to define social and political science: "Not merely the science of political economy but the science and philosophy of the just and equitable form of government based upon the great fundamental law that nations and men should do unto each other as they would be done by." In other words, he was injecting the element of values, which I must confess as a social scientist we have too often sidestepped. We winnow the census volumes for statistics and coefficients of correlation, but we shy away from making value judgments and Peter Cooper wanted to provide against that common failing so far as his teachers were concerned.

Difficulties

Well, you say, yes, sure, that's a good idea, but what are the "bugs" in it? What are the difficulties that you are going to encounter if you try to broaden and deepen the curriculum of the technical institute student?

I hope that if I have any contribution to make to this group it is in terms of experience. Dean Hammond, as chairman of the committee that I referred to, influenced the Society of Engineering Education to set up a Division of Humanistic-Social Studies. I was fortunate enough to be selected as the first chairman of that Division and served for four or five years. My trustees thoughtfully provided me with an administrative assistant to cope with the vast amount of correspondence and visitations that that report of 1944 stimulated. We gained quite a lot of experience in the implementation of the humanistic-social stem in engineering education, and I would venture to say that the problems that we encountered are pretty much the kinds of problems that you will find if and when you get into this field.

Our first difficulty was a matter of teaching personnel. It is obvious that the inspired young Ph.D. instructor is usually more interested in the minutia of his researches than in broad generalizations and stimulating the interest and enthusiam of freshman, sophomore, or junior engineers. However well prepared the professional teachers of English and social sciences may be, their own personal interests are not always toward this kind of "service" teaching. The ASEE very properly sponsored a number of summer institutes following its annual meetings and they successfully created an atmosphere of enthusiasm on the part of these young teachers and made it possible to exchange ideas and techniques of teaching.

Then we found that on the larger campuses it was very difficult to get separate departments of English, history, economics, philosophy, and sociology to work together on a coordinate program. The engineering dean had to go around and ring doorbells and he usually became pretty discouraged. The letters and correspondence we received revealed rather startlingly the cold shoulder that he received from the other deans and heads of departments. We advised the engineering dean to go to the president of the university and put it up to the president if it was beyond his scope to get the cooperation he was entitled to. We felt it was up to the president or one of his administrative officers to see to it that the dean got the proper cooperation. It was rather paradoxical that the engineering colleges that stand alone were in a good deal better position to control the teaching of the humanities than the larger universities that actually had much greater

academic resources. It is a sad commentary on the ability of educated people and scholars to work together but that was found to be one of our most common difficulties.

Tool Courses

We found that an approach by tool courses assisted in the acceptance of enriching the engineering curricula in these areas. In other words, to start in with English composition and public speaking and to teach them from the broadest possible point of view was a good way to begin. But it was found by the same token that some resourceful deans of engineering would tend to call almost anything "humanistic-social studies." Athletics, orientation, and even summer surveying camp were mislabeled or at least mis-classified in order to reach the recommended goal of 20% of the engineering curriculum to be devoted to this area.

And then we found that a number of engineering deans would say, "Well, we don't just want economics taught or English taught; we want English for engineers; we want economics for engineers." I suppose some of them might really look for music and art for engineers. We were completely and fundamentally opposed to that. If there is any validity to the field of economics, it is economics. The economic process and the economic institutions are fundamental. There isn't any more a brand of engineering economics than there is a brand of engineering algebra. It's economics; it's algebra.

Another difficulty was the demand on the part of some deans for a tailor-made program. Perhaps they had met some lack of cooperation and rebuff the first time they tried to organize a curriculum and they would write us at Cooper Union and say, "Now won't you just give us what seems to be a good well-balanced program and we'll take it to the president, and then it will be up to him to put it through." Of course, you can't organize an educational program that way. You have to set it up in terms of the campus resources in personnel, library facilities, and all the rest of it.

And finally the initial resistance that you will find on the parts of the students was startling. You may have won over the faculty, budget-wise and every other way, and your problems seem pretty well solved. Then, all of a sudden, you discover that the students will have none of it. That's exactly what I found in 1939, the year that I organized the Department of Humanities at The Cooper Union.

Let me tell you a little story to illustrate this point. We had a senior that year who was the top man in the electrical engineering course. He was so indignant about having to take a course in Social Philosophy that he not only went to the head of the department and to the dean but he came to me. "What a waste of time!" he said. Three hard long years to get up to the senior year in which he hoped to study everything that we had to offer in the field of electrical communications and now we were going to make him waste three hours a week studying Social Philosophy! Well, we argued with him, we cajoled him, and finally we compelled him to take the course. The end to that story was as follows: being the brightest boy in the class, he was also the valedictorian. What did he take for his valedictory address? A subject on electronics? No! He picked "Utopias." And why did he pick Utopias? Because he said he was so intrigued with his course in Social Philosophy and at man's efforts to draw blueprints for a better society that he wanted to share with his classmates and his friends in the audience the excitement and the inspiration that he had received over that course in Social Philosophy.

You *can* win them over, and you *have* to win them over if your program is to be effective.

What To Do About It

Now, finally, how and what to do about it. I've indicated that the teaching staff must be won over to the general program.

Then, of course, they are going to say, "Well, but the jug is full; how are you going to find the time?" It's true, the jug is full, and I'll suggest how to find the time. You will have to re-examine and rethink the validity of each subject in your curriculum. You'll have to decide whether or not that course in drawing really requires twenty-three plates or whether, by better teaching, you can give them just as much skill and practice by doing thirteen plates. We did that at Cooper Union. We doubled the number of instructors and we halved the number of drawing plates. It can be done if you have a courageous and inspired faculty that is willing to improve its teaching. I understand from Holderman's article in the April 1952 *Technical Institute News* that fifty per cent of your teachers are college graduates. There is no magic, I believe, in the college degree, but I think the better the education, the better the background your teachers have, the more ready they will be to take on experimental programs, and that is certainly true in the field of the humanistic-social studies.

We believe at The Cooper Union, a professional school devoted entirely to professional work, that the extracurricular activities and student government are very important and that much of what I am recommending can be achieved outside the classroom; in fact, a good deal can't possibly be taught in the classroom. It can only be done in terms of an inspired group of teachers who are willing to give their time to the students and provide continuity to the avocations and outside activities. Finally, on the organizational end of it, I recommend that a department of instruction for the humanistic-social studies be organized. I find in looking through the catalogs of a number of technical institutes that while there are many scattered offerings there is not much evidence of a departmental organization and inspiration or leadership.

Tremendous Challenge

As I have said, the jug is full, but let me point out that the jug rests on a great big saucer and this great saucer that can take the spillover for this new injection of material is the years following graduation. The motivation of students to continue their avocational interests will be a by-product of what I am urging and if it is successful they will want to carry on after graduation. Of course, you will want to be sure that industry recognizes the value of the graduate of the technical institute.

Your public relations programs should be stepped up as far as I can see in all of your communities. I think the American public has been over-sold on the value of the bachelor's degree and I am glad to see that the "degree" of associate in arts, the associate in science, as well as the general validity of the junior college program in general, are being recognized. It is a most hopeful thing in our American scene.

I think you should encourage your local public school systems to establish more of these institutes. They need to be expanded, or perhaps they need to be established. Finally, I suggest that you appoint a committee to study the problem as the engineers did in 1940 and 1944.

You have a tremendous challenge ahead of you. You alone can decide whether or not you will be turning out grease monkeys or citizens during the fateful second half of the 20th century.

National and Regional Developments in Cooperative Evaluation and Accrediting Activity*

By EWALD B. NYQUIST

Chairman, Middle States Association of Colleges and Secondary Schools, Commission on Institutions of Higher Education

I am not unmindful this morning of that rare occurrence which a general educator experiences when he secures as a captive audience not only a group as large and as promising as this one, but one which represents a single profession.

I have been asked to present to you a summary of the current status and activities of the National Commission on Accrediting, the present status and activities of the Middle States Association, and its collaborative relationships with the Engineering Council for Professional Development.

Status and Activities of the National Commission

First of all, let me define the National Commission. Seven national educational agencies, like the Assocition of American Colleges and the Association of Urban Universities, contribute six members each, all college and university presidents. It is supported by a membership of some 1200 higher institutions. Although its history goes back a long time, the National Commission was really born as such in 1949.

Its predecessors and the National Commission were concerned primarily with what they regarded as the evils of accrediting and first debated the issue of whether there should be any accrediting activity at all, but that matter was soon settled. The National Commission arrived at certain principles which it considered would conserve the values and abolish the evils of accrediting.

I think these principles can best be summarized in the time available by presenting the policy statements contained in a progress report sent by the National Commission to its membership as of September 4. I have included some others it had established previously.

1. Improvement of higher education in all of its parts is best achieved when based upon thorough self-evaluation prior to examination by outside specialists.

2. Institution-wide aims, objectives and responsibilities should be given primary concern and evaluations should be concerned with the institution as a whole as well as with its various segments.

3. Colleges and universities through the six regional accrediting associations should be the responsible and supervising authority for evaluation of higher educational institutions.

4. Channels through which the counsel and suggestions of the professions and employers of graduates can continually reach the institution should be maintained.

5. Accreditation costs and the number of visitations should be kept at a minimum. For accrediting purposes, not

* Presented at ASEE—ECPD Joint Program with ECRC and ECAC, New York City, October 16, 1953.

more than one organization should represent a field of training.

6. An acceptable program of accreditation should be fostered on a nationwide basis.

7. Accreditation should exist primarily as a stimulus to institutional growth and development rather than be merely a standardization based upon minimum criteria.

The over-all objectives of the National Commission, I think, have been regarded as laudable by almost all accrediting agencies, regional or professional. I should like to emphasize the word, "overall." In an attempt to consummate these objectives, however, the National Commission was at first imperfect in approach. For instance, after declaring a moratorium in accrediting activity, by January 1, 1954 it wanted all higher institutions to cease paying dues and accrediting fees to professional accrediting agencies, and, furthermore, all regional accrediting agencies were supposed, by that date, to be responsible for all accrediting.

Communications on specific matters from the National Commission were often confusing, sometimes unrealistic, and not infrequently illustrated the practice of the adoption in advance of arbitrary positions. At any rate, the initial activity of the National Commission touched off a first-class national ferment in education.

I am sure that the National Commission has certain important accomplishments to its credit:

1) It has stimulated all accrediting agencies to examine their purposes and objectives.

2) It has certainly reduced abuses in accrediting.

3) It has contained accreditation and confined it to certain limits and agencies.

4) It has provided accrediting at large with a definite purpose and objectives which accrediting did not have before.

5) It has in effect, provided a firm basis for national development and improvement of accrediting activity.

Last July, I attended a meeting of the Executive Committee of the National Commission. I am quite sure that the National Commission intends to pursue its overall objectives in a spirit and form different from those which characterized its earlier efforts. More realistic proposals will be made; the cooperation of all groups whose interests are at stake will be more solicited than demanded.

Status and Activities of the Middle States Association

I turn now to the Middle States Association and its Commission on Institutions of Higher Education, of which I am Secretary.

The Middle States Association is one of six regional accrediting agencies. Its area of activity, geographically, includes the States of New York, New Jersey, Pennsylvania, Maryland and Delaware, the District of Columbia, Puerto Rico, and the Canal Zone. It has existed since 1887. There are about 221 member institutions. Any higher institution is eligible, college, university, junior college, specialized, technical, or professional, so long as it has a program, at least 2 years in length, if at the undergraduate level, or of one year, if at the graduate level.

Our Commission is composed of 15 educators, mostly presidents, but of varying positions in colleges and universities and of diversified backgrounds. We have a central office and a full-time paid assistant.

First of all, I should like to cite some principles which control the organization and operation of our Commission.

The Middle States Association

1. Considers and helps every institution within its purview.

2. Gives proportionately the same consideration to large institutions that it gives to small ones.

3. Considers all programs within institutions in their relation to the institution as a whole.

4. Adjusts its standards in terms of a cross-section of the accredited institutions within its purview rather than in terms of marginal institutions or in terms of the highest ranking ones.

5. Enlists the largest possible number of participants in its membership of colleges and universities.

6. Operates with minimum paper work and minimum cost.

7. Provides for constant criticism, review, and readjustment of its criteria and its procedures.

8. Examines an institution in terms of how well it consummates its purposes and objectives. It has no matrix to press upon an institution.

9. Provides for growth through the stimulus of self-evaluation.

10. Employs qualitative criteria.

11. Is essentialy under the control of the institutions launching and supporting the program.

12. Treats institutions and their staffs with the dignity they warrant and honors their essential freedom and autonomy.

Relationships of Middle States Association with Professional Agencies

Now let me provide you with a little insight into our detailed procedures of evaluation and accreditation. At the same time I will stress those features which represent cooperation between ECPD and the Middle States Association. I might point out that our Commission has met with representatives from 26 professional accrediting agencies representing 22 distinct fields of interest. We have agreements with each of them along the lines of the one now in effect between ECPD and the Middle States Association.

1. Institutions being evaluated in any one year are those which are non-member institutions seeking initial accreditation and member institutions re-evaluated every ten years under normal circumstances. Simply organized institutions are evaluated in February or March in any one year. Complex institutions are evaluated in the fall. Initial arrangements for joint evaluations are made by the Middle States Association. Our schedule for evaluations is known for some years ahead for two reasons: Collaboration with professional agencies requires it and the institution must conduct a self-evaluation.

2. Questionnaires to be filled out by the institution are sent in advance of the visitation. Part A of this Questionnaire calls for data of common interest to the ECPD and the MSA and is answered once for the whole institution. Part B of the Questionnaire has been worked out jointly with ECPD and deals with the Program, Outcomes, and special problems of a particular unit in a complex institution and is to be answered only by the unit concerned. We have as many forms of Part B as there are areas of specialized and professional interest. In an institution with a single program, like liberal arts, the institution answers Part A and our own form of Part B.

Every member of the visiting committee receives, in cases of complex institutions, a copy of the university report, Part A, and those evaluators concerned with instructional units, like a School of Engineering, receive a copy of the report pertaining to that unit, Part B.

3. Every two years we ask member institutions to submit nominations of volunteer evaluators for use by our Commission in forming evaluation committees. About 1200 nominations are received and include every kind of person as far as position and background is concerned. Letters are sent to about 600 of these nominations to see if they will in fact be available in the near future. About 300 to 400 of these 600 are actually used by us.

4. Chairmen of the committees include all Commission members and an appropriate number of others drawn from those people who have served the Commission well in the past. The Committees include at least a majority of experienced evaluators.

5. The Committees used number no less

than 5 for any type of institution and may number up to 40 or 50 depending upon the complexity of the institution. Our Committees, in representation, reflect the organization and teaching functions of the institution being visited. For simple institutions, besides the Chairman, there will be one expert in Finance, one in Library, one in Program, and one in Organization. In complex institutions, having professional instructional units, expert personnel are added for each professional unit within the institution. In addition, in large institutions, we will add experienced people in areas like student personnel, admissions and records, intercollegiate athletics, and the like. Finally, on each Committee is a representative from the State Education Department in the State in which the institution is located which is done to eliminate the duplicate legal activity of the State.

When we evaluate an institution with an engineering unit, we request ECPD to furnish the expert personnel required. They represent ECPD as well as the Middle States Association and are integral members of the committees on which they serve, with the same responsibility toward the MSA as the other members and such special responsibilities toward ECPD as ECPD may direct. Usually this responsibility is the same one exercised by ECPD evaluators when the cooperative agreement now in effect did not exist.

6. Instructional materials are supplied all evaluators in advance. The Chairman also coaches his team. All members serve for nothing except the Chairman who receives a small honorarium. Committee members are reimbursed for their expenses which are billed finally to the institution. There are various financial arrangements with the professional agencies, including ECPD; in any case, one bill goes from the MSA to the institution and where formerly professional agencies did not charge for their independent visits, we do not, under present cooperative agreements.

7. The visit is made on a date convenient to everyone and the institution and lasts from 2 to 4 days.

8. During the evaluation, conference and discussion within the committee are emphasized. Each one has a particular assignment but each also has a voice in and a responsibility for the MSA report as a whole.

9. The report is prepared by the members are supplemented by sections on Purposes and Objectives and Outcomes prepared by the Chairman. Members representing ECPD write their reports analyzing engineering curriculums in their usual manner and these reports are included within the total institutional report.

10. Our commission meets twice a year and considers the original Questionnaire material, the report of the Committee, and an oral presentation of the Chairman.

11. a) The decision on the institution is then made. Certain substantive actions can be modified by procedural modifications calling for reports of progress to be submitted at certain dates by the institutions concerned or for subsequent modified visitations, usually informal for the purpose of observing at first-hand improvements made in weak areas.

b) Our Commission's decision to accredit an institution applies to the whole institution including its constituent units. The balance of factors in the institution's favor determines its accreditation. Therefore, an institution can be accredited as a whole even though some of its constituent units may be weak. On the other hand the Commission does not hesitate to deny accreditation to an institution in instances where specific weaknesses are evidenced in any programs, professional or otherwise, or in intercollegiate athletics, such that the educational effectiveness of the institution as a whole or its institutional integrity has not been demonstrated.

c) In instances where the institution is accredited as a whole even though there are weak constituent units our Commission expects within a certain time period

that such substandard programs will be improved and their weaknesses corrected. Failure to do so constitutes cause for denial of continued accreditation.

12. The institution may appeal from any decision of the Commission to the Executive Committee of the whole Association.

13. Personnel used on Committees are rated by the Chairmen. Those who are only fair or unsatisfactory are never used again.

14. All members of the committee, including the professional representatives, as well as the institution, receive copies of the final report.

Evaluation Process

I would like to summarize, for your benefit, the main points of the evaluation process of the Middle States Association where they are affected by virtue of the cooperative agreement made with ECPD.

1. We have agreed to exchange confidential information about institutions of mutual concern when such an exchange will strengthen the evaluation procedures of each agency and of course the institution concerned.

2. ECPD has agreed to designate for inclusion on our evaluation committees, evaluators who will represent both the MSA and ECPD.

3. We have agreed that reports of ECPD evaluators will be included in our total reports.

4. We have agreed on a joint Questionnaire, Part B which will be given a trial period this year.

5. We have agreed to exchange projected evaluation schedules for the purpose of attempting to collaborate in overall evaluations, as frequently as commitments of each agency permit, particularly in this transition period.

6. We have agreed to centralize the billing of an institution for the costs involved in order to reduce confusion and inconvenience for the institution concerned.

7. We have agreed that ECPD, in evaluating under these arrangements those curricula which are subject to its re-inspection or for which an institution voluntarily asks ECPD's accreditation, will also evaluate remaining areas in the field of engineering in order to give the MSA report a meaningful coherence.

8. Aside from these specific agreements, generally, I believe it is the intention of both agencies to collaborate in every way possible. The entire agreement is experimental for both sides for one year, after which the whole codification will be re-appraised.

The benefits to be derived from our cooperative arrangements would seem to be a better knowledge and understanding of the institution as a whole by all concerned; a reduction in duplicative activities and overlapping costs; a lessening to some degree in the movement toward entrenched departmentalism; and an appraisal of the institution and its various parts made available to it in the final report developed on a joint basis.

The MSA cherishes the cooperative agreement reached with ECPD, and all the more so because it was the first complete agreement reached and consummated by joint visitation between the MSA and any of the 26 professional agencies we are working with. A comity of relationships based on mutual respect and confidence is being established between ECPD and our Association.

Every detail of our plan will not always work out completely satisfactorily. Yet we believe that further common experience will lead to clearer insight, and that there are no insuperable problems in the type of cooperation projected.

Necessary for the Country

The plan for this type of cooperation is envisaged by the National Commission to be necessary for the country and not just the MSA. The other regional associations are not as far advanced as the

MSA is in this type of approach. You will, as a national professional agency of specialized and professional interests, encounter some problems in the future. I hope I do not convey to you an impression that the MSA is claiming a monopoly on wisdom and virtue in having proposed the broad outlines of the agreement now reached with ECPD. I mention the suggested difficulties because I realize in working with you your national interests.

Finally, let me give you the viewpoint of the MSA concerning its plan for and philosophy of evaluation and as they relate to professional agencies and the National Commission on Accrediting.

The MSA and its Commission on Institutions of Higher Education are the creatures of, and are in every respect responsible to, the member institutions of the MSA. Our Commission is not concerned whether specialized agencies publish their own accredited lists, and in so doing, maintain their own integrity as accrediting agencies of specialized interests. This question is outside of our Commission's province. It has no authority either to permit or to prohibit their doing so. It has no authority or mandate from its membership to absorb the functions of other organizations. It does not claim exclusive jurisdiction concerning accreditation in its territory.

Single Mission

Our Commission on Institutions of Higher Education has as its single mission the fostering and improvement of the quality of higher education in the Middle States area. Since evaluation and accrediting of institutions are among the Commission's means to that end, the MSA is interested only in improving and strengthening evaluation procedures when it seeks cooperative agreements with agencies of specialized interests.

Our Commission does not establish or enforce the requirements of any professional accrediting agency or of the National Commission on Accrediting, excepting its own membership. Its interest is in the educational effectiveness of the institution as a whole, viewed in the light of each institution's own aims and purposes.

I should like to close with a slight paraphrase of a recent statement made by Chancellor Kimpton of the University of Chicago:

"To change if it is done wisely is to progress. To resist change is to bear witness to the quality and distinction of what we already possess. So long as we do both these things with vigor and with vehemence you need have no worries about the future of your" accrediting affairs, engineering education, and their relationship to the Middle States Association.

In the News

Dr. J. E. Morton, professor of statistics at Cornell University, Ithaca, New York, has been appointed consultant on industrial research to the **National Science Foundation.**

Opportunities for University Research in Heat Power*

By R. G. FOLSOM

Professor of Mechanical Engineering and Director of Engineering Research Institute, University of Michigan

The theme for the session "What is our job in Heat Power Education or Research?" presents a challenging question for consideration. As a start it might be well for us to define what we mean by research. In the broad sense, research may be considered as the individual or group effort of critical and exhaustive investigation toward discovering new facts or devising old methods or theories. It is essential that this investigation shall result in an original contribution to the field of knowledge concerned. It has been common practice to classify research into three general headings. First, basic or fundamental research; secondly, applied research; and thirdly, development. A recent survey of the engineering schools by Ralph Morgan of the National Science Foundation shows that the educational activities of a college or university in engineering associated with research should be about half basic and half applied, with no effort being devoted to development. Although the implication that engineers should not be concerned with the development phases of research is far-reaching and important, this phase will not be considered in detail in these remarks.

Staff members at colleges and universities undertake research activities in the field of engineering for the education of students and staff, as well as for the purpose of making a contribution to the available knowledge in the field of engineering. The emphasis and encouragement of research activities varies from school to school, and is frequently limited by the availability of funds and the assignment of staff time for this activity. It should be noted that research is the very heart of graduate work, and as a result, an essential element in staff activity in any school engaged in graduate instruction.

Scope of Activities

In considering applications of research to heat power, a definition of the scope of activities is desirable, one such being "the broad field of machines which use a working substance, subject to thermodynamic variations." The differences in basic and applied research will be considered with respect to the field of heat power. This is important since what is considered as basic research in engineering might be applied research in mathematics, physics, or chemistry. For our purposes, we will consider basic or fundamental research as that creative effort which results in new information having no direct application to any design, machine, or process. Applied research, on the other hand, refers to that creative effort which results in new information directly useful for design, machines, or processes associated with heat power. It should be noted that performance testing of equipment is not research in the sense discussed here, unless such performance

* Presented at the Annual Meeting, A.S.E.E., Heat Power Section, University of Florida, June, 1953.

tests result in an analysis which presents unique information.

During this meeting of this Society, considerable discussion has developed in connection with the accreditation of engineering curricula. Some recommendations regarding professional-general and professional-scientific engineering curricula have been proposed by the Committee on Evaluation of Engineering Education. Research in heat power engineering can be directed toward either the professional or scientific activities of the field. "This professional engineering activity is characterized by the economic design of high level, non-routine problems requiring integration of the results of scientific research. It is further identified by synthesis, judgment, compromise, and feasibility." (This definition is taken from a recommendation of the Graduate Studies Division of the A.S.E.E.)

The activities in the field of heat engines may be classified as basic operations, combined operations, and performance of machines in plants. What is meant by basic operations may be defined through consideration of combustion. The basic or fundamental operations underlying combustion may be considered as dynamics, fluid mechanics, heat transfer, mass transfer, reaction kinetics, and thermodynamics. Taken alone as individual subjects, basic research will be found applicable to investigations in these fields of science important to engineering. When the phenomenon of combustion is concerned, the basic operations are no longer independent but mutually affect one another. In order to investigate combustion phenomena, it then becomes necessary to consider the combined operations. On the other hand, combustion may be considered as a basic operation to steam production, which is composed of many basic operations. Steam production is of course one of the combined operations making up the steam power plant as a whole.

Research Problems

Research opportunities at a university or college are concerned primarily with the basic operations. This limitation is the result of limited funds, manpower, and equipment available to undertake investigations. In the event that combined operations and plant performance research is to be undertaken, aid from external sources in the matter of equipment and funds becomes of prime importance. It should be remembered that a college or university has many specialists on its staff who are available for consultation, and thus the educational institution can make major contributions to research through the efforts of the staff members.

If we assume for the time being that activity in research is a desirable effort in the field of heat engines, the usual staff member is confronted with the problems of what is an appropriate topic, what are the sources of funds, can additional assistance be obtained, and what can be done with the results.

Many considerations are involved in the selection of a suitable topic, but the major requirement is the enthusiastic interest of the man undertaking the investigation. We have indicated that consideration of the basic operations is the most fruitful field for research in educational institutions.

Using the list of theses in the Division of Mechanical Engineering at Berkeley for typical examples of subjects of interest to heat power engineering, particularly in the basic operations of fluid flow and heat transfer, we find the following examples:

1. Turbulence in Liquid Pipe Flow.
2. Local Boiling on Vertical Tubes.
3. Viscosity of Gases at Elevated Temperatures.
4. Stability Considerations in Vertical Annular Two-Phase Fluid Flow.
5. Accuracy in Reading Aircraft Instrument Dials as a Function of Time of Observation and Dial Brightness.

6. A Calorimetric Determination of the Constant Pressure Specific Heats of Carbon Dioxide at Elevated Pressure and Temperatures.
7. Performance of a Variable-Compression Engine at Elevated Temperatures.
8. A Water Channel Analogy to a Problem in Gaseous Combustion.
9. Heat Transfer to Mercury in Turbulent Pipe Flow.
10. Heat Transfer and Pressure Drop for Air-Water Mixtures Flowing in a Horizontal Tube.
11. Mass Transfer in a Rising Bubble.
12. An Experimental Investigation of Convective Heat Transfer to Air from a Flat Plate with a Stepwise Discontinuous Surface Temperature.
13. Effect of Packing Density in a Cross-Flow Cooling Tower.
14. Starting Thrust Loads for Deep-well Turbine Pumps.

In addition a study of "Review of Current Research and Directory of Member Institutions" made by the Engineering College Research Council of the American Society for Engineering Education will be helpful.

Research Support

Funds to support research are available from many sources, and the following gives some indication of the possibilities. Usually the university or college has limited funds available for research, either by departmental appropriations or by special appropriations earmarked for specific investigations. Industrial companies have established fellowships to aid graduate students in doing research. Most of the engineering societies have limited funds available to support research, as for example, the A.S.M.E. Fluid Meters Committee, which has supported and is supporting research and testing activities at several universities. Foundations have made large sums of money available for research activities, such foundations being Carnegie, Rockefeller, Guggenheim, and the Research Corporation. Recently, large sums of money have been available for research activities in colleges and universities from various government departments, particularly those associated with defense. Some of these are the Office of Naval Research, National Advisory Committee for Aeronautics, Bureau of Ships, the Signal Corps, Office of Ordnance Research, Office of Scientific Research, National Science Foundation, and the National Research Council.

As noted previously, research may be conducted on an individual or team basis. In the event that the work is of such scope that team effort is advisable, the staff members and graduate students available in an educational institution may be utilized. The staff investigator who undertakes a research activity may hire the qualified personnel if suitable funds are available. Or he may make use of professional and non-professional employees of the educational institution and the research activities of graduate students working for their degrees.

In industry the results of research usually appear as patents or new products of the company concerned. In an educational institution (a non-profit organization) the results of research frequently take the form of publications in the transactions of the engineering and scientific societies and the publications of the educational institution.

The opportunities for research in a particular subject in the field of heat power may be limited at any one university or college due to the local conditions. On the other hand, opportunities for university research in heat power are bounded solely by the individual's own limitations. "Where there is a will, there is a way."

ASEE Summer Institutes—1954

Science and technology are moving rapidly ahead in broad areas which hold significant promise for the future of engineering. In order to assure maximum progress in engineering education and to expedite the translation of new fundamental concepts into engineering practice, the American Society for Engineering Education is inaugurating this year a series of conferences to be known as Summer Institutes. This program will help to implement the recommendation of the ASEE Committee on Engineering Education that modern physics, including nuclear science and solid state physics, should become an essential study in engineering education.

Each Summer Institute will deal with a specific subject matter area. The purpose of the Summer Institute is to seek out and clarify fundamental concepts, to assess the material as to its importance in engineering education, and to arrive at a logical orderly pattern for teaching purposes. By this positive approach, it is hoped to bring engineering education into closer proximity to the significant new developments which will affect its future. In these conferences, the divergent viewpoints of the research engineer, the scientist, and the educator will be brought to bear upon the problems.

Two Summer Institutes are planned for 1954—one in Sold State Physics in Engineering Education and the other in Nuclear Physics in Engineering Education. Both conferences will be financed by grants from the National Science Foundation. Each Summer Institute will consist of a working conference of 20 to 30 leading authorities in the particular field who will make a comprehensive analysis of the material and lay the groundwork for the open conference. The open conference will feature about 6 to 8 of the participants of the working conference, discussing important fundamental concepts and organization of the subject matter as it relates to engineering and engineering education. There will be ample opportunity for open discussion by those in attendance.

These conferences are supported in part by grants from the National Science Foundation. The American Institute of Physics is cooperating in the Nuclear Science Foundation.

Solid State Physics in Engineering Education

University of Illinois—March 8–10, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Carnegie Institute of Technology—June 21–25, 1954

Open to engineering and physics teachers. Attendance will be limited to 150. For information and registration forms write to Professor John W. Graham, Carnegie Institute of Technology, Pittsburgh, Pa.

Nuclear Science in Engineering Education

Columbia University—April 22–24, 1954

This will be a working meeting of leading physicists and engineers specializing in this field. Attendance by invitation only.

Northwestern University—September 7–11, 1954

Open to ASEE members. Attendance will be limited to 100. For information and registration forms write to Professor Robert L. Young, Technological Institute, Northwestern University, Evanston, Ill.

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ASEE Summer Schools—1954

The following Summer Schools, sponsored by ASEE Divisions, are open to ASEE members. For information and procedures as to registration, please write to the person indicated in connection with the particular Summer School. All of the Summer Schools at the University of Illinois either precede or follow the Annual Meeting so that those in attendance can combine Summer School attendance with attendance at the Annual Meeting. The program for the Annual Meeting of the ASEE will be mailed to Society members during the last week of April.

Economics of Engineering Summer School sponsored by the Engineering Economy Commitee.

Theme: "An Evaluation of Analytical Techniques of Engineering Economy."
Time: June 12–13, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Arthur Lesser, Jr., Head, Industrial Engineering Dept., Stevens Institute of Technology, Hoboken, N. J.

Electrical Engineering Summer School sponsored by the Electrical Engineering Division.

Theme: "The Elements of Design of Digital Control Circuits."
Time: June 18–20, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Dr. L. V. Bewley, Dean of Engineering, Lehigh University, Bethlehem, Pa.

Summer School in Advanced Engineering, with Emphasis upon Development of Creative Thinking jointly sponsored by Educational Methods Division and General Electric Co. Attendance by invitation only.

Time: Aug. 30–Sept. 4, 1954. *Place:* Schenectady, N. Y.
Information: R. H. Buescher, Technical Education, General Electric Co., Schenectady, N. Y.

Workshop for Humanistic-Social Project sponsored by Humanistic-Social Division.

Time: June, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Sterling Olmsted, English Dept., Rensselaer Polytechnic Institute, Troy, N. Y.

Engineering Mechanics Summer School sponsored by the Engineering Mechanics Division.

Theme: "Evaluation of the Engineering Significance of Graduate Training in Mechanics."
Time: June 11–12, 1954. *Place:* University of Illinois, Urbana, Ill.
Information: Professor Dan Pletta, Virginia Polytechnic Institute, Blacksburg, Va.

Summer School sponsored by the Mechanical Engineering Division.

Theme: "Teaching of Machine Design and Manufacturing Processes."
Time: June 18–25, 1954. *Place:* University of Illinois, Chicago, Ill.
Information: Professor K. E. Lofgren, Machine Design, Cooper Union, New York, N. Y.

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Symposium on Instrumentation Education

Co-Sponsors: Instrument Society of America and American Society for Engineering Education.

Location: University of Illinois, Urbana, Illinois.

Date: June 12, 1954.

Purpose: To focus attention on the concepts, subject matter, and methodology of technical instruction in the broad areas of measurement, computation, control and systems studies. Chairman: Professor R. J. Jeffries, Michigan State College, East Lansing, Mich.

8:00– 9:30 A.M. Registration.

9:30–11:30 A.M. Universal Characteristics of Instruments—H. C. Roberts, University of Illinois.
Situation Analysis in Instrumentation—W. McKay, MIT.
Concepts in Measurement—D. J. Montgomery, Michigan State College.
Computation and Computers in Engineering and Science Curricula—L. L. Rauch, University of Michigan.

Industry Comments.

Discussion.

12:15–1:30 P.M. President's Luncheon—Speaker: W. A. Wildhack, President, ISA.

1:45–3:45 P.M. Teaching Control Engineering—R. W. Jones, Northwestern University.
Teaching Systems Engineering—H. Sohon, University of Pennsylvania.
Teaching Instrumentation Engineering—C. S. Draper, MIT.

Industry Comments—H. W. Cory, Allis-Chalmers Co.

Discussion—A. F. Perry, Panellit Corp.

4:00–5:00 P.M. Inspection of University facilities for research and teaching activities in measurement, computation and control.

Graduate Professional Education in Engineering*

By M. P. O'BRIEN

Dean of Engineering, University of California, Berkeley

The proposal made is simply that one branch of the graduate program in engineering be truly professional in character, with the primary emphasis on the solution of novel and difficult engineering problems. Such a program should parallel and not replace the traditional masters and doctors programs in which research in the engineering sciences forms the central activity. Many individual graduate students have probably been permitted to follow a plan of this type and it may be well-established in some American schools but, if so, the writer is not aware of this development. In many European schools, the program leading to the first engineering degree is of this general character.

Engineering education in this country was organized in response to the demand for men capable of participating in the rapid national expansion of the last century. The initial pattern was derived from schools established somewhat earlier in Europe but was modified to meet our own needs. The Land-Grant College Act aided in expanding this type of education. In the early days of engineering education it was not evident that science could contribute directly to the solution of engineering problems and, in fact, there were few demonstrations of this applicability. Early instruction dealt chiefly with the art of engineering; courses were practical in nature; professors were drawn from practice and gave a great deal of their lecture time to discussions of existing engineering works. Later, the curricula in the engineering colleges were modified to give greater attention to the basic and engineering sciences for two very good reasons. In the first place, there was the need to give engineering academic respectability. This was accomplished by greater emphasis on chemistry, physics, mathematics and such engineering sciences as strength of materials, analytical mechanics and so on. Secondly, there was increasing evidence that a knowledge of science could and did contribute directly to the successful practice of engineering. With the total time limited to four years, this increasing emphasis on science necessarily resulted in a decrease in attention to professional studies and on the whole this change was desirable and beneficial. However, in the course of making these changes, there has developed the implied assumption that engineering consists solely in the application of science; more important still, that those who are well grounded in science are automatically well qualified as engineers. This concept has led, I believe, to an undue emphasis on scientific knowledge and to a de-emphasis on the application of knowledge to the solution of engineering problems. It is this general subject which I will discuss.

Expansion of Graduate Study

The four-year undergraduate program has been the basis for successful engi-

*Presented at the Annual Convention of the Association of Land-Grant Colleges and Universities at Columbus, Ohio, Nov. 11, 1953.

neering practice on the part of all but a small fraction of the profession. In the face of this record of success, why should there now be an expansion of graduate study, especially study of a professional character? My answer is that the tools which the engineer will use in the future will continue to grow in number and complexity and that a longer period of education is required for their effective use. There will always remain a large volume of work in the technical field for which the four-year program will provide adequate preparation. However, there is a rapidly widening segment for which additional study is now highly desirable and for which an additional one to three years of graduate study will be regarded as essential in the not very distant future. Probably, seventy-five per cent of the B.S. graduates in engineering would not benefit from additional study but the remainder will, I believe, find themselves handicapped unless they somehow continue their formal education. The percentage now choosing to engage in graduate work is much less than the twenty-five per cent who are qualified and for whom such work would be beneficial.

Why do so few B.S. graduates in engineering choose to pursue graduate studies? One reason is that the engineering faculties have themselves regarded the four-year program as adequate preparation for practice and have, more frequently than not, implied that graduate study was a frill, unnecessary for serious practitioners. Industry has not strongly supported the position of graduate study in the overall professional scene and the professional societies have not, until recently, formally recognized it as a necessary part of the pattern of engineering education. Even more important, perhaps, is the apparent lack of financial encouragement to the holders of advanced degrees. These and other circumstances are often cited to explain the lack of interest in graduate study among B.S. engineering graduates. There is, I believe, a more fundamental reason for this situation, namely, that graduate study in engineering as now organized does not fully meet the needs of the profession and would not benefit a majority of those who should proceed beyond the four-year course.

Engineering education like professional engineering practice is plagued with confusion and haziness regarding the terms used. Even the word engineer is the subject of controversy. In order that there be no misunderstanding regarding what I have in mind when I speak of professional engineering, science, and engineering science, I will take time to define these terms.

Engineering

Engineering is frequently referred to as the application of science—with the implication that all engineering works were preceded by corresponding discoveries in basic science. This description of engineering is not only oversimplified but is historically incorrect. Bridges, irrigation systems, aqueducts, and even the steam engine, were built without benefit of scientific principles; today, large segments of engineering practice depend more on experience, judgment, and "rule of thumb" than on science. This situation, affecting some but not all branches of engineering, does not result from ignorance or stupidity on the part of engineers but rather from the absence of general relationships permitting a more analytical and scientific approach.

What, then, is the nature of engineering? The characteristic engineering activity is the design or planning of machines, circuits, structures, or processes —and of combinations of these components into systems or plants—and the prediction of their performance and cost under specified operating conditions. Note particularly that "the prediction of performance and cost" is here considered to be the characteristic activity and

that performance is not mentioned alone but rather "performance and cost." Without money considerations and the emphasis on cost, professional engineering would be a different sort of an activity. Prediction of the performance of novel or greatly modified designs is usually more difficult than predicting costs but the two are related, the engineering effort being primarily to discover which design will involve minimum cost.

Whether this definition of engineering is generally acceptable or not, the activity described, namely, prediction of the performance and cost of engineering works, is a major phase of the practice of engineering and one which depends heavily on design methods and information derived from the engineering sciences.

Science and Engineering Science

Research is a search for truth. In the physical sciences, research aims at discovering new facts and new relationships in nature. The velocity of light, the temperature of the sun, the composition and structure of a mineral are examples of facts resulting from scientific exploration. When such facts are related to other facts in a quantitative way the result is called a law of nature. Newton's law of universal gravitation, Archimedes principle governing the buoyancy of submerged bodies, and Einstein's theory of relativity are examples of these relationships. The complexity of nature, considered in large aggregations, is so great that scientists working in the basic sciences have been forced to think about, and experiment on, idealized and simplified systems, such as frictionless fluids, particles in high vacua, processes in reversible equilibrium, perfectly elastic bodies, and so forth. In spite of these limitations, the results of scientific research have been of great practical value and have affected profoundly the daily lives of all of us.

Just how can these scientific facts and relationships be translated into forms useful to society? Did the discovery of Newton's laws produce directly a watch or a gyroscope? Did the discovery of nuclear fission produce an atomic bomb? The answer is, of course, that there is a long and frequently tortuous patch between the discovery of a new physical fact or relationship and its incorporation into useful "hardware." The phenomenon of atomic fission made a bomb possible in principle—but much work and many dollars were required before the bomb became a reality. It is the area between the basic sciences and engineering design in which lie the engineering sciences.

The terminology of this subject is not well established, even among engineers. The *engineering sciences* include such technical subjects as fluid mechanics and its subdivision aerodynamics, thermodynamics and heat transfer, metallurgy, combustion, acoustics, electronics, and many others. The term *applied science* is some times used but *engineering science* more accurately describes the relationships involved. The better known and most widely used of these subjects, in one guise or another, form the core of the conventional curricula in the engineering colleges.

I have taken time here to define my concept of engineering, of science, and of engineering science because graduate study in engineering has in the past aimed chiefly at extension of the student's background into the engineering sciences; only to a limited extent has it been concerned in any direct fashion with preparation for professional engineering. A large fraction of the graduate students in engineering schools should continue to concentrate their efforts on research in the engineering sciences.

Problems of Engineering Education

The engineering colleges have pursued a number of objectives in preparing their

educational programs. All of them hope that their work will prepare their graduates for creative work in the engineering field. Their efforts in this direction are, however, beset by a number of conflicting conditions which should be kept in mind. In the first place, the practice of engineering requires a degree of conservatism which is not characteristic of scientists. The engineer who experiments with his client's money by introducing new and untried concepts or materials is not true to the traditions of the profession. An engineer must review what has been done of a similar nature, must weigh the evidence for introducing a new material or new method of design, and must in many ways show a high regard for past experience. Engineering schools and engineering professors reflect this attitude; perhaps reflect it so strongly at times as to avoid the new concepts which will characterize engineering practice in the future. This characteristic conservatism conflicts in many ways with the development of ingenuity, creativeness, and originality in the student. It is difficult to ask a man to be both conservative and original at the same time but both are necessary characteristics of the engineer practicing in an advanced field in which new applications of science are being made. Another factor is the evident necessity for placing great emphasis on knowledge in engineering education; however, knowledge alone will solve almost no problems of consequence. If one can "know" the solution to a real problem, it is not an important one. It is necessary that the student acquire and exercise as early as possible the ability to apply his knowledge to the solution of novel problems and this is not an easy prescription to fulfill. A third consideration is that a large percentage of the professors in engineering colleges are not in reality professional engineers. This situation is understandable; few young men who choose engineering in college do so with the expectation of becoming professors. Thus there are engaged in the formulation of programs of engineering education, a group who, in general, are not intimately and personally familiar with engineering practice. A fourth consideration is that the practice of engineering in this country involves the organization of teams of engineers who by their combined effort make up for the fact that the inventive genius is rare and cannot possibly be distributed equitably among the companies and agencies of government who need technical services. Any one company cannot depend for its future growth on employing and developing the genius of a Ford or an Edison or a Westinghouse; industry has assured itself slow but steady progress through the organization of groups of men with technical educations. The education of these average, rather than unusual, men engages the major attention of the engineering colleges.

Original Premise

Engineering curricula have, in their evolution from descriptions of empirical arts to professional programs of an analytical character, tended to retain, nevertheless, their original premise that the practice of the future would not change substantially from that of today. Science has been added but narrow specialization remains. Engineering educators should consider carefully the warning of Vannevar Bush who stated in a recent speech:

"Specifically, there may be a tendency to turn to the engineer only for those things that are so matured that they have begun to appear in handbooks, and to turn to the applied scientist for a novel approach—for the new and pioneering activity that is especially attractive from an intellectual standpoint. Much of the training of engineers leads to a compartmentalization that contributes directly to this tendency. Who would think of tossing to a young electrical engineer a tough problem in the chemical engineering field? Yet this is just the sort of thing that we must expect as our industrial effort becomes more ramified

and as the problems we attack become more interwoven with the whole fabric of diversified science that is now being utilized, unless we are willing to abdicate to the applied scientist the most congenial part of the engineer's function. I fear that only too often the young man with a scientific background is more flexible under novel circumstances than is the young engineer, and this is much to be regretted. It is to be regretted because we cannot give up the most cherished attributes of our profession-versatility and resourcefulness—without making our jobs unattractively one sided and conventionally drab."

The late H. P. Hammond stated in Mechanical Engineering:

"Somehow, somewhere in the undergraduate years, the student should be given the opportunity to do a little original work on his own initiative, under guidance of teachers, of course, but not under the close direction which prevails to the end of the curriculum. A great fault of engineering education is to dampen the spirit of enterprize and the desire to create with which most of the students enter college. Instead of tending to stifle originality in our students, the reverse should be the case; we should plan to encourage it. The effects of the introduction of an opportunity for original work on the part of the students is a revealing experience."

If this most desirable objective can be achieved in the undergraduate program, it will be the prelude to the professional graduate program—and perhaps will largely eliminate the need for it. Dean Hammond's statement is effectively a summary of my proposal, transposed to undergraduate years.

Requirements for Successful Engineering Practice

Engineering in the sense defined here is concerned with the expenditure of money—other people's money, public or private—and this responsibility engenders a conservative attitude which accepts innovation only after critical examination. A major problem of the engineer, and of engineering education, is to be conservative and, at the same time, be receptive toward change. An erroneously low estimate of initial or operating costs may lead to an unwise decision to invest; conversely, estimates which are erroneously high may cause the loss of a profitable opportunity. An unduly optimistic or pessimistic feasibility report on a proposed development may be disastrous.

Another major factor in the practice of engineering is the necessity for decision on schedule and on the basis of the data at hand. If the engineer takes time to investigate fully and conclusively every element of uncertainty in a major design problem, the expenditure of time and money would be prohibitive and the results would usually come too late to be of value. Faced with the necessity for decision and conscious of his responsibility for the prudent use of capital, his conservation causes the engineer to recommend that design which, in his judgment, involves the least risk. The engineer should not embark blindly on a program simply to meet a schedule; a more usual difficulty is the inability of engineering graduates, especially in their early years, to reach a decision on the basis of the evidence at hand. One can always imagine many analytical and experimental jobs which should be performed before reaching a decision and thus postpone the fatal day when the decision must be made. However, the engineer who is conscious of the cost of engineering works, realizes that undue delay in making a decision increases the cost and also defers the day when the work itself can become productive.

Impelling Urge

An impelling urge to solve the problem which needs to be solved is, I believe, the most characteristic feature of successful engineer-designers. In this respect engineers differ greatly from sci-

entists. The latter are free to choose their problem. The engineer is forced to solve the problem given him, usually solve it within a time limit. The most successful engineers of my acquaintance are those for whom the strongest motivation is the need for a solution. When their company or their organization is faced with a problem, that problem becomes for them the most important and interesting one they can imagine. If an engineer cannot acquire this viewpoint, he is not likely to be successful.

Engineering work is performed by teams. Few engineering works can be said to have been designed by one man. The ability to cooperate and to fit into an organization is important at the outset; later, the successful engineer will direct the work of other engineers and scientists, many of whom will be the product of educational disciplines different from his own. Not only must he possess the personal qualities for leadership but his knowledge and experience must be adequate for *technical* leadership.

The engineer must develop an intuitive understanding of physical phenomena sufficiently strong to make him "feel" the effectiveness of a proposal, prior to quantitative analysis or experimentation. Study of the basic and engineering sciences, vicarious experience through observation of the works of others, and service under the direction of competent engineers, will develop and strengthen his judgment but, at some point, he must strike out on his own. The earlier he does so, the better off he will be.

Overriding all the preceding requirements for successful practice is that of creativeness—the ability to recognize or imagine the problem, to conceive a feasible solution, to analyze this concept and reduce it to a design, and to bring it to reality in workable "hardware." Perhaps creativeness cannot be developed; it can at least be exercised and the education of engineers should take precautions not to inhibit it where it is latent. There is a shortage of creative engineers. A few such men can generate enough ideas to absorb the energies and talents of hundreds of less gifted engineers, who can analyze, test, report-on, optimize, and otherwise polish an original idea but who are not themselves creative. Men of varied talents are needed in the engineering team and all perform valuable services, but the creative individual is essential. He must first be found and then nurtured. The fundamental position of ingenuity and creativeness in engineering practice cannot be overemphasized. Until someone visualizes the basic principles applicable and conceives an assembly of parts which is likely to accomplish the specified purpose, there is nothing to analyze and no subject for the quntitative application of the basic and engineering sciences. True, much of engineering consists in the modification of concepts already applied but this is true of the work of the traditional practitioner and not of the engineer of unusual talents for whom effective graduate study should be provided. No deprecation of the steady, reliable, common-sense designer is here intended; he will continue to perform valuable services as in the past. One is not better than the other; they have different talents and are suited for different types of work. The graduate program should not be opened up to all B-S graduates, most of whom should start acquiring experience as early as possible, but only to those who have shown indications of special talents.

The Graduate Professional Program

What I suggest in the way of a graduate professional program consists in a central core of novel and difficult engineering problems which the students attack, initially in small groups and later, after gaining experience, individually. These design problems should cut across the conventional areas of scientific and professional specialization, as do almost

all problems of engineering practice, and at least a few of the resulting designs should be built and tested. The student should be responsible for choosing and defining the problems attacked and appraisal of his progress should give weight to the significance and importance of the problems chosen.

Primary emphasis on the solution of complete engineering problems will supply strong motivation for studying the related basic and engineering sciences and for reviewing related designs critically as the secondary and supporting part of the student program. Formal courses judiciously selected must be relied on for most of the scientific background but extensive reading and consultation with the faculty will be essential in the solution of suitable problems.

Why not leave professional experience in design problems to practice? Is there a good reason to take time away from course instruction for work of this character? Young muscles are made strong by exercise. True, good food, the right parents, plenty of sleep and other conditions contribute to physical superiority, but the athlete must practice his sport and must do so vigorously enough to develop skill and stamina. There is an analogous situation in engineering practice; a good mind filled with useful knowledge is not sufficient. Interest in the practical solution and judgment developed by experience are essential; delay in applying knowledge to engineering problems may, and in my opinion frequently does, result in mental indigestion. There is for each individual some optimum balance between the rate af acquiring knowledge and exercise in applying it, and it is the purpose of the type of program I have in mind to improve this balance for those students whose ability, interest, and aptitude justify the educational effort. A second reason is to be found in the nature of modern engineering practice, which is almost universally a team effort. The graduate who has not developed some competence in attacking "whole" problems must serve an apprenticeship on routine work under close supervision before he will be given even a minor degree of responsibility. This situation results in further delay of the time when the young engineer faces the problems of independent design. A substantial start in this direction should be made early, preferably in the undergraduate years, and a graduate program emphasizing advanced professional studies will satisfy a very substantial need.

It is sometimes said that the student cannot work effectively on the solution of engineering problems until he has acquired and sharpened the necessary tools; he must master all of the basic and engineering sciences before attempting their use. A quotation from Maritain, the French philosopher and educator, is pertinent to this contention:

> "What is learned should never be passively or mechanically received, as dead information which weighs down and dulls the mind. It must rather be actively transformed by understanding into the very life of the mind, and thus strengthen the latter, as wood thrown into the fire and transformed into flames makes the fire stronger. But a big mass of damp wood thrown into the fire only puts it out."

Maritain would probably object to being quoted in support of a proposal for professional education, but learning a great deal about science, without reasoning through to applications, affects the engineering student's "fire" in much the same manner.

Implementation

Implementation of a program of professional education of the type visualized will require the intimate association of a professional engineer-teacher and a small group of students working on problems in the general field of interest and competence of the teacher. Organization on this basis will be expensive

but so is almost all effective professional education. It is my contention that, if engineering schools are to provide the professional practitioners of the future in the numbers and with the ability which will be needed, they must get away from the present mass production type of organization with its inflexibility of program and its emphasis on organized courses and must move in the direction of individual study. In such a program, one is interested both in the results produced and in the processes by which the results are achieved. By this I mean that the appraisal of the student should not be solely in terms of whether he had devised a workable design but rather whether he has, in the course of working out his problem, increased his capacity for the solution of future problems. A technique which might be employed to some extent in the early phase of a program of this type would be to redesign or reinvent existing machines, circuits, structures or processes so that the student might compare his results with those which already had been achieved. The final problems, the master's thesis or the doctor's thesis, should be novel and difficult, should require the application of science, and should create something potentially useful either in research or in engineering practice. It is important that the engineering faculty make available to engineering practitioners the result of research in engineering sciences in such form as to be readily understandable and applicable and, in this process, the graduate student in the professional field can play an important part.

Graduates with the type of background visualized in the preceding remarks are urgently needed in industry and government, not only for engineering work but also to provide a supply of managers—both in engineering work and in general management—for companies engaged in the technical field.

Faculty Need Professional Experience

The most important factor in the success of any educational program is the quality of the faculty provided. Some faculty members do acquire the viewpoint of a professional engineer without themselves engaging in professional practice, but it is my observation that these qualities can seldom be developed to a reasonable degree without substantial professional experience. Consequently, it does appear that successful implementation of this proposal will require men on the faculty who have practiced engineering at an advanced level of responsibility and who have themselves been subjected to experiences which will have impressed upon them the importance of the qualities previously outlined. These qualifications of faculty members for a professional program are difficult to meet because men who have the intellectual ability, the experience, and the viewpoint are in great demand in industry. It is unlikely that the engineering colleges can be fully competitive in salary with industry for men of this calibre, but the salaries must be nearly competitive and other considerations must make up the difference. It is desirable that these faculty members continue to some extent their association with professional practice.

Teaching Tips

Is the Project Method Effective?

By D. G. HUBER

Assistant Professor of Mechanical Engineering, University of Toronto

In the recent admirable report of the Committee on Improvement of Teaching of the ASEE, the project method of teaching engineering was recommended highly as an aid in the development of student resourcefulness and originality. This paper is written in the hope that some benefit might result from the experiences of one who has used this method for several years in the teaching of Hydraulics.

In this subject, as in many others, the customary practice has been to use the laboratory periods to supplement the lecture courses directly, by giving a series of short, difficult, unrelated problems and experiments and requiring written reports on each. This method can be effective in training the student in specific skills, and a great variety of work can be covered in a comparatively short time. Usually, however, inertia dictates the use of the same or similar problems year after year; the interest of the students is maintained with difficulty; copying of reports becomes a problem, and the whole system seems to be directed towards the obtaining of marks and the passing of the final lecture examinations. Certainly, student resourcefulness and originality are not developed, nor is an attempt made to correlate the work of the specific subject with problems of a broader nature such as must be met later in practice.

The project method was attempted at the University of Toronto as an alternative, in the hope that it would be made effective by maintaining the advantages of the above method while minimizing the disadvantages. Each group doing the study averaged in number thirty-five final year Civil Engineering students, and the time allotted was about forty-five hours.

Outline of Project

The problem was the design of a flood control or power project on an existing or fictitious river. Each student worked as a consulting engineer and wrote an engineering report advising on the feasibility and desirability of the project. The illusion of reality was maintained by the requirement that a statement of consulting fees be included with the report. The problem necessitated the use of hydrologic studies, statistical methods, dam design, river hydraulics, turbine selection, highway relocation, electrical load studies and an economic analysis.

Difficulties Encountered

In the three years in which the project method was used many difficulties and criticisms were met in part by changes in the original system. Some of these difficulties and their attempted solutions are listed below.

(a) *The project method tends to cover a broader field, but does it rather superficially.* Proponents of the value of repetition and the disciplines in teaching engineering will object to the project method because there is not enough time nor direction of the students' work to ensure a mastery of engineering skills. This difficulty has been mitigated, to some

extent, by a careful selection of the conditions of the problem, so that a portion of the course which it is desired to emphasize will appear in each student's work, and then informing him that this must be done more thoroughly than the rest, under staff direction.

(b) *Students work at different speeds.* Should a student who works slowly be penalized for not finishing, or should the faster student be held back? There is some merit in learning to pace oneself against time, even at the expense of thoroughness. In this project it was emphasized that the students are working against themselves and not each other. Thus, each was expected to complete the project to the best of his abilities, the faster man getting his reward in the more detail he was able to cover. Marks were given more for the effort and resourcefulness shown than for the final result.

(c) *Students tend to bog down in detail.* It must be pointed out to them constantly that the time spent in details should be relative to the importance of the details to the final result of the project. Thus, the design of a minor element, costing perhaps one per cent of the total, can be done approximately with little effect on the final cost.

(d) *This method encourages over-simplification of a problem.* Because of the emphasis on finishing the work in a certain time, simplifications of the details of the problem must be made. Care must be taken to point out where this is done, what other studies should be made and how the necessary information would be obtained in practice.

(e) *Student Cooperation is essential for success.* It is inevitable that some students with little interest in the subject will attempt to take advantage of the latitude given by this method. On the other hand, it has been found that most students appreciate a change in the old "lock-step" methods and are anxious to do their best. Thus, it is essential that a frank explanation of the theories behind and reasons for the project study be given, together with a plea for cooperation. To ensure this cooperation, a diary of each day's work was compulsory and a frequent inspection of work books was made. Sufficient penalties for non-cooperation were included in the marking system.

(f) *Students have not been pre-conditioned for this method.* Some students are unable to adapt themselves quickly to this method and may flounder for a considerable time unless given some special attention. The diary and the work book enable early detection of this type of student.

(g) *The fear of losing marks reduces the effectiveness of the study.* While competition among students for marks has some desirable features, it tends to stultify resourcefulness in anything but obtaining marks. Everything the student does is coloured by the marks which may be obtained. This can be reduced by emphasizing that marks are given for effort and progress rather than for the best solution. The students are assured that failure will result only from lack of honest effort or a deliberate flouting of the rules.

(h) *The results of the study may be mediocre.* Each report should be read carefully and a written criticism given in which weaknesses in design, analysis and presentation are pointed out.

(i) *The student is not prepared as well for his final examinations as previously.* This may be true if the examination requires merely the parroting back of information handed out in the lectures. Surely the examination should be a test of thinking power and resourcefulness as well as of knowledge.

Evaluation of Results

In the writer's opinion, the project study as described has been a success. Student interest has been more than satisfactory; resourcefulness, initiative and

originality have been stimulated; a correlation of Hydraulics with other fields of engineering has been achieved; the importance of economic analysis has been spotlighted; the difficult practice of writing an engineering report has been attempted and the connection between academic theory and practice has been emphasized. In addition, the student has become familiar with various reference sources. He has been treated as an adult and given freedom of choice and action within broad limits. Surely these results outweigh the disadvantages.

The project method is effective—why not try it?

ASEE Annual Meeting Program for Women and Children

University of Illinois, Urbana, Illinois—June 14–18, 1954

Monday, June 14—Welcoming Tea; Family Square Dance and Mixer.

Tuesday, June 15—Trip and Luncheon, Robert Allerton Estate.

Wednesday, June 16—Engineering Properties and Decoration of Dinnerware; Luncheon, Bridge and Canasta, Champaign Country Club.

Thursday, June 17—New Textiles, Their Care and Use; Fancy Ice Cream Demonstration.

A full program for children has been planned, including games, crafts, lunch as a group, swimming and entertainment with engineering wives and children in charge. Be sure to bring your bathing suits and caps!

Baby sitter listings available at Women's Headquarters, Illini Building. Children under four years of age are not eligible for the children's program. Register the children as far ahead as possible for the program so that they can be accommodated.

Candid Comments

Your invitation, on page 223 of the *Journal* for December, is too tempting to resist. The report on engineering integrity by Dean Freund's committee provokes both thought and comment.

It is assumed that this committee has just undertaken the first step in its challenging assignment—defining a general area of ethical motivation as it relates to professional conduct. For it is obvious that before plans can be made for teachers to mix the instruction of ethical conduct in with their instruction of science and technique, it will be necessary to come to grips with specific behavior patterns that are acceptable, or unacceptable, to our profession. Yes, it may be necessary first to reach a common understanding of what constitutes acceptable conduct under quite specific circumstances.

Perhaps there is general agreement among engineers as to the manner in which an engineer should behave under specific circumstances. However, our codes of ethics are not complete in many areas and there is ample, accepted misconduct in some areas as to threaten the maturing of engineering as a profession. I had better give some examples, before this too becomes another general statement of philosophy.

1) All engineers steal ideas. Perhaps the word "steal" is too blunt. The very growth of the profession depends upon a free exchange of information. Taking and building onto another man's ideas is an acceptable, even an essential behavior. The stature of an engineer, and his ability to create and be compensated adequately depend upon his facility in the use of ideas of others and the degree to which he can pile up some new ones of his own. Thus it has become customary to acknowledge the source of ideas, and give credit for accomplishments. Yet, how common it is for an engineer to accept credit for—even seek credit for—ideas stolen from another. Those familiar with engineering literature are aware that occasionally the name affixed to an article is that of the person who had general administrative supervision of the work described rather than the man whose ideas are represented—in fact the man who actually wrote down the words describing those ideas. Co-authorship sometimes eases the twinge of conscience remaining.

In the "promotion" or sales of services it is quite common to overlook or depreciate the accomplishments or ideas of another—even someone in the same organization—in the drive for recognition, advancement or economic advantage. It is all too easy to present somone else's ideas as your own. But it is stealing nevertheless.

2) Too many engineers bear false witness. It is common practice in some areas of engineering employment to create a false picture of the importance or extent of a project, for the intent of expanding an organization or continuing an operation that has no measurable value. Modesty, honesty and accuracy are considered to be secondary in importance to job tenure or advancement in such areas. Or, how often our organized profession has been injured by malicious or uninformed misstatements of fact by a spokesman for one group or another, who seeks competitive advantage for his own small segment of the profession. Yet these spokesmen are occasionally heaped with honor and raised to positions that indicate clearly that their conduct is to be taken as a good example.

3) Too many engineers worship the false god of job security to the neglect

of their own growth and creativeness. This conduct in itself can reduce engineering from the status of a profession to that of a technical occupation. (Indeed it is now so considered by many both inside and outside the group.) The persons who seek job security in legal controls or collective collusion, and neglect or refuse to expend their own intellect and energies creatively threaten the status of engineering as a profession.

These are but a few examples. They have not been defined clearly. Certainly there is wide difference of opinion as to the point of ethics involved. Yet it is in areas of human relationship such as these that patterns of behavior are developing that will increase the ability of our profession to contribute constructively, and to be recognized for such contributions—or that will reduce the status of engineering. The key is not to be found in more legal controls, or in more vocal "pressure group" operation.

It is heartening to anticipate that Dean Freund's committee will define some of these behavior patterns, seek agreement on the point of ethics involved, and then offer recommendations for effective instruction in such concepts. They should have every encouragement.

Very truly yours,
DON P. REYNOLDS,
Assistant to the Secretary,
American Society of Civil Engineers

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

New Members

ADAMS, LEONARD C., Associate Professor of Electrical Engineering, Clemson College, Clemson, S. C. J. H. Sams, F. T. Tingley.

ALLEN, JEREMIAH M., Instructor in English, University of Colorado, Boulder, Colo. W. S. Beattie, B. H. Spurlock, Jr.

ALLEN, R. W., Associate Professor of Mechanical Engineering, University of Maryland, College Park, Md. M. S. Ojalvo, D. R. Keller.

ALLEY, CHARLES L., Assistant Professor of Electrical Engineering, University of Utah, Salt Lake City, Utah. Lee Harrisberger, P. C. Pfister.

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Section	*Location of Meeting*	*Dates*	*Chairman of Section*
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Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
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How Much Research Should Engineering Schools Do?

By ERIC A. WALKER

Chairman, ECRC, and Vice President, ASEE, Dean, College of Engineering and Architecture, The Pennsylvania State University

Before World War II, schools of engineering did very little research; that which was accomplished was done by professors as an avocation or as some small projects done by the graduate students in engineering, and some small programs supported by such groups as the National Research Council and the Edison Electrical Institute. Engineering schools, like most industries and scientific organizations, really got into the research business during the war. Although a great deal of the research work was definitely of the applied kind, much of it was directed by physicists. Many engineering school staff members found themselves either in the Armed Forces, working in Government laboratories, or in industry during hostilities. It was not until near the end of the war that engineering colleges, through their experiment stations or research departments, got deeply involved in Government research.

It was expected that the end of the war would bring a relaxing of pressure on engineering schools to do contract research for both industry and Government. Such has not been the case, and with the coming of the Korean conflict, the volume of work being done by the engineering colleges was again increased. In 1952, this country spent nearly $3,000,000,000 on research and development. This is almost 1 per cent of our gross national product. Of this sum, $1,640,000,000 came from the Government, and most of the remainder from industry, with a small fraction from foundation and university funds. Of these funds, $280,000,000, was spent for research in the universities, $830,000,000 for research in Federal laboratories, while the remainder was spent in industry.

At the present time, according to the "Review of Current Research" of the Engineering College Research Council, over $65,000,000 * is being spent annually by its hundred-odd member institutions. This engages at least part of the activity of 13,000 faculty members and graduate students. The Directory itself covers 7500 projects which provide over 5000 separate entries in an index. The volume of research approximates the importance of student instruction as far as the number of staff members and the business offices are concerned. Recently, there has been much concern about the possible future of such research and development in the engineering schools. There is no doubt but that there will be a tightening of the military budget, and probably less money will be available for research anywhere.

As research funds are reduced by Congress, someone will have to take a cut. It is difficult to reduce the amount spent

* The apparent discrepancy between this $65,000,000 and the figure mentioned previously is that the $280,000,000 includes research in biology, psychology, and the other "soft" sciences, as well as the amount spent in large university laboratories (like Project Lincoln) which are operated by a university but not directly connected with the teaching function.

in Government laboratories because the level of effort is largely established by the facilities available and the ceiling on Civil Service positions. These "ceilings" have little current relationship to the operating funds and are not easily reduced. On the other hand, industrial research contracts are often associated with development and production, which affords an additional reason for not reducing research in industry. Therefore, many educators expect that the funds available for engineering school research will be reduced most sharply.

Research Tends to Become Programmatic

There are those who would regard this as a blessing in disguise. It is easy to recount the reasons why military research is not well-adapted to the college campus. Foremost, of course, is security. Even if a college decides to indulge only in fundamental and unclassified research, it finds that if important new results are obtained, the research, though still fundamental, has a tendency to become classified. Contractual difficulties are always present. The uncertainty of re-negotiation and the indeterminate length of contracts which still require the use of personnel with tenure are not conducive to easy and happy relationships between the college, the Government, and the professor. As has been pointed out before (1), Government and even industrial research tends to become programmatic. The research worker becomes a slave to a program and is not the scientific adventurer he would like to be.

Government programmatic research is not done without cost to the university, even though all identifiable costs are covered by overhead. Now at least one defense agency, in considering new proposals, has started to ask universities to identify their financial contribution to the support of military research programs before such proposals are considered.

Recently, hopes have risen that much of the basic and fundamental research previously supported by the military may soon be supported by the National Science Foundation. This change, if accomplished, may reduce the programmatic restrictions, but it will impose an additional financial burden on the colleges. In Department of Defense research, it is customary to pay for hidden costs in an item called "overhead," which usually amounts to about 45 per cent of the total sum paid for salaries and wages. Since salaries and wages, in general, run about half the contract expense, this means about 22 per cent of the total contract figure is paid to the colleges to cover hidden costs. In the National Science Foundation program, this overhead is calculated as 15 per cent of the total contractual sum. Such a contract thus immediately imposes a 7 per cent additional burden on the college if a program is moved from the Defense Department to the NSF. Additionally, the National Science Foundation prefers the college to provide the supervisor's time or salary and, if it is in accordance with the college's policy for other grants, to employ graduate students and remit the graduate tuition fees. These additional expenses are not inconsiderable, and most colleges could not afford to transfer all of their Department of Defense research to the National Science Foundation. However, against such difficulties one must balance the absence of security measures, the lack of the programmatic straight-jacket, and simpler accounting procedures.

These considerations again raise the question of why engineering colleges do research anyway. Many of us have leaped this hurdle by blithely and superficially quoting, "It is the duty of a college to advance the frontiers of knowledge." Engineers are not concerned only with advancing the frontiers of knowledge; they are concerned with producing machines, devices, and systems which will satisfy human needs.

Creative Aspects of Engineering Education

The major emphasis of engineering education is now turning to the creative

aspects of education. This dictum was first clearly expressed by Hollister (2) and it now is the main theme of the ASEE's Committee on Evaluation Report (3). Then, can one say categorically that if we want to teach our students to be creative, we ought to have a creative faculty? If the answer is "yes," it implies a faculty should be competent to take the results of research and create the new devices people want. This conclusion is the core of a policy statement now being discussed by the institutional members of the Engineering Research Council. If it is accepted, then all engineering colleges should have active research, development, and *design* programs.

The difficulties in constructing and managing a research program for an engineering college are many. There are many staff members who express a wish to participate in research and development but who have no idea of how to go about it. They are merely moths attracted by the candle. There are others who could spend days and years on problems which are of no importance. There is nothing wrong with this use of time if the pursuit of an insignificant question is an avocation. It may be as valuable a recreation as golf and tennis. The point is that an engineer shouldn't expect to be paid to do recreational research if it is pointless or without intrinsic value. The collecting of useless data has no engineering value.

Some would claim all data are useful and some day will be needed in an important engineering design. This is somewhat akin to drilling a hole in the ground just anywhere because one might hit oil. An engineer is expected to drill for oil where his data and reasoning tell him there is a substantial possibility of striking oil. Engineering research should be done in areas where there is an economic need for new discoveries.

Some teachers might work for years on a research problem and never produce a paper or a design which can be published or used. Therefore, most schools, even if they had adequate funds to support a fundamental research and development program, would not have a mechanism developed to use those funds efficiently.

Recently, the National Science Foundation, in attempting to find out what funds could be used properly in the engineering colleges, made a survey of the number of engineering teachers who were engaged in programmatic research and identified those who would prefer to pursue exploratory research and development programs if they had the choice (4). Such data are useful in setting the financial boundaries for research.

Funds Needed for Research

A different way to estimate the funds needed for research is to ask each faculty member how much of his time he would like to spend in creative pursuits *if* he could be relieved of an equivalent percentage of his teaching load. The danger in such a question lies in the fact that it is too easy to give an answer without any thought to what work should be done and what the final product might be. As a trial, the faculty of the College of Engineering and Architecture at Penn State was asked these three questions:

(1) What percentage (10, 20, etc.) of your time would you like to devote to creative engineering activities while being relieved of a proportionate share of your other duties?
(2) On what problems would you work?
(3) Where and in what form would you expect to publish the results of your research? (Be specific.)

The questions were prefaced by an explanatory statement intended to give the teacher pause so that he would think carefully before putting down an arbitrary percentage. The results of that survey are given in the following table:

No research or did not answer	54
10% time on research	5
12½% time on research	1

15% time on research	2
17½% time on research	1
20% time on research	31
25% time on research	6
27½% time on research	1
30% time on research	11
33⅓% time on research	3
35% time on research	1
40% time on research	2
50% time on research	12
	130

In the above table, all those who did not bother to reply were considered as having insufficient interest in research and therefore were recorded as zero.

A question then arises, "How much would it cost to put an adequate research program into effect?" There are a number of ways of calculating this, all susceptible to very large errors. However, one might clearly identify the conditions under which the calculations are made and then use the figures as a guide.

The questionnaire shows that 76 people out of 130 wished to participate (this excludes department heads and other administrative help). This means 20 equivalent full-time people are required to do the research indicated or to cover the teaching load of those who wish to devote part-time to research. This is 20 out of a total teaching faculty of 130, or approximately 15 per cent.

With a teaching budget of $750,000, this requires that funds available for salaries must be increased by $125,000. Since this covers faculty time alone, it gives the minimum possible increase.

Suppose we went one step further and assumed that in addition to paying for teachers' time during the academic year, we were willing to pay the man for two months' vacation time and provide adequate funds for equipment, supplies, communications, etc. This produces quite different and larger figures. The number who would engage in summer work is not the 20 full-time people, but all 76 who indicated a desire to do research in our institution.

These people would be paid for two months' summer work, so our figures look something like this: During the academic year, 20 full-time people at an average salary of $5750 equals $125,000. For the summer months, 76 people at an average salary of $5750 paid for two months equals $87,400. A reasonable amount for equipment and supplies might be $1000 each, giving a total of $288,400. This represents a 38.4 per cent increase in the academic teaching budget to support the desired research.

Further Extrapolation

Let's look at it one more way. Suppose that these calculations were based on the normal National Science Foundation method of financing. In cases like this, the National Science Foundation is pleased if the college can underwrite the salary of the professor during the academic year, but they do believe that it is desirable to underwrite the summer months and to pay salaries for graduate students who are doing work toward advanced degrees. Last year the average NSF grant in engineering was $6500 per year, and each one supported an average of 1.25 graduate students. If a similar program were adopted for the 76 people who have desirable programs, the cost to the college would be the $125,000 mentioned previously as needed to pay their salaries during the academic year. The cost to the National Science Foundation on these averages would be 76 times the average grant, or $495,000. However, this would provide for summer employment for all 76 of these people and would provide a means of support for 95 graduate students.

If these percentages, which were established on the basis of this very small sample, were extrapolated to all the schools, the National Science Foundation bill for research in engineering would be $26,000,000 per year to support the research programs of 4600 out of 8000 engineering teachers. This is enough extrapolation.

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College Notes

A short conference on New Developments in Structural Design will be offered at **Virginia Polytechnic Institute**, August 4 through 6, under the sponsorship of the Department of Applied Mechanics. The program will be of direct interest to all structural designers and architects of the region, and will be presented from a practical point of view. It will cover topics embracing the design of structures subjected to impulsive loadings such as those resulting from atomic blasts, the elastic and plastic behavior of the materials and component structural parts, and the elastic and plastic analysis of two and three dimensional structures. All speakers are well known throughout the engineering world for their contributions to research in their respective fields. It is the intent of this conference to reduce the time lag between the publication of such contributions and the use of such material by actual practicing engineers.

Pratt Institute will offer a program leading to the degree of Master of Industrial Design in the academic year 1954–1955. Candidates must have a bachelor's degree in design, architecture or engineering and show promise in advanced design and product planning. A total of 32 semester hours is required for the degree.

* * *

A graduate course in the application of nuclear energy to industrial uses will be offered this fall in the evening division at **Illinois Institute of Technology**, Chicago. It is designed for students who hold B.A. degrees in engineering and have completed differential equations. Registration for the course will be held from 6 to 8 P.M. on Friday, September 17, at 3300 Federal Street, with classes beginning the week of September 20.

Dependence of Engineering Leadership on Mechanics and Physics*

By L. E. GRINTER

President of A.S.E.E.; Dean of the Graduate School and Director of Research, University of Florida

Important discussions have been taking place on nearly all campuses of engineering colleges during the past year concerning the future trends in engineering education. Since these discussions relate primarily to the professional-scientific core of the engineering curriculum they center around the subjects of mechanics and physics. There could be no professional engineering without these subjects which encompass many of the fields of study and research commonly classified as the engineering sciences.

It is indeed worth while to take time to look into the engineer's responsibility for the advancement of knowledge. For the first two or even three decades of this century the engineer's responsibility for new developments was strictly limited to applications of science and to the development of the art of engineering. He completed the development of great suspension bridges as an extension of Roebling's art without adequately sensing his responsibility for learning more about bridge vibrations and pulsating wind forces. Engineers developed radio partially as an art, but when applications began to outgrow the extension of the art, physicists were of aid in establishing basic theories of wave phenomena which gave rise to electronics as we now find it in our curricula.

Physicists were busy in research in the fields of engineering science, i.e., dynamics, elasticity, plasticity, fluid flow, thermodynamics, heat transfer and electronics until their attention was drawn away by their overwhelming responsibility for guiding all the numerous studies and applications of modern physics. It seems evident that there is more work to be done in modern physics than all the talented physicists can do in our lifetime. Hence, to engineers has fallen the responsibility for furthering our knowledge in the fields of engineering science, and to a considerable extent this work lies within the realm of engineering mechanics. Either mechanics men must move the field of engineering science ahead or in many places it will remain stagnant and unfruitful.

Training for Leadership Tomorrow

The question that has arisen simultaneously in the minds of a great many engineering educators is what influence should this new responsibility of the engineering profession have upon the basic training of engineers? A second great influence, our growing responsibility for nuclear energy applications, enhances the importance of this question. Nuclear engineering is an accepted area of employment although we give it no specific place in our usual curricula. Within the area of nuclear engineering there are being studied, developed and rapidly placed into use hundreds of new materials and processes. Our graduates have had no contact with these new developments, and they can have none with the amazing developments

* Presented before the Mechanics Division, Annual Meeting of A.S.E.E., University of Florida, June, 1953.

that so clearly lie immediately ahead. Over and over we have to ask ourselves the following question: Are we really giving young engineers the basic training that fits them for leadership not today but a decade or a generation ahead? The extent to which our curricula resemble those of the 1930–1940 era contrasted to the extent to which engineering methods of 1975 will diverge from engineering practice today gives us some measure of present inadequacies in engineering education. It would be comforting to feel that this lag in the educational process is normal and natural, and that young engineers have always had to overcome such handicaps. This would be true if engineering and science had been passing through a natural evolutionary period of development. Instead, the greatest scientific revolution of all time took place with the development of nuclear power. Engineering as applied science did not feel this revolution as early as physics and several other sciences. However, engineering is now being strained to the limit to fulfill its obligation to apply nuclear power to both war and peace. Engineering educators cannot disregard these forces, which, with the persistence of gravitation, continue to draw engineering education in the professional-scientific direction. As engineering educators face the realities of the great influence that modern physics will soon be playing in the field of engineering applications, I believe they will insist that their professional-scientific students study nuclear physics and physics of the solid state at the undergraduate level.

Specialization

At present we are building considerable specialization in the art of engineering into the curriculum at the undergraduate level in order to justify the use of the professional engineering designations or specializations of civil, mechanical and electrical engineer. These specializations have less significance today than they had a generation ago when one could accomplish very little until he knew the specialized art involved. In the future even more than today we can expect the fields of engineering science to be more significant as fields of specialization than the professionally accepted groupings. Our approach to a solution to this problem is to forget the traditional requirements of a narrowly professional nature and to let the student acquire the degree with professional designation of civil, mechanical or electrical engineering largely upon the basis of education in the field of engineering science. At a group meeting of twenty mechanical engineers interested in the field of mechanics I publicly noted that all except two had been trained as civil engineers. This is strong evidence, I feel, that we are overly specialized in our restrictions upon the award of designated undergraduate degrees in engineering.

Clarify Conflicting Issues

The Committee on Evaluation of Engineering Education can go little further than to clarify the conflicting issues that are struggling to be recognized in engineering education. Traditionally our institutions fortunately are free to reach their own decisions. I do not foresee or urge an immediate radical change in the pattern of engineering education. I do urge a fuller consideration of the need for a much larger percentage of young engineers well trained to enter the professional-scientific side of engineering where they will use their talents to work with and to interpret the work of physicists, chemists and other scientists for the purpose of making appropriate applications and to contribute by their own research to the advancement of the engineering sciences.

In order to increase the precentage of such engineers we will need curricular adjustments at the undergraduate level with increased emphasis for particular individuals in the study of MATHEMATICS, PHYSICS, CHEMISTRY and the ENGINEERING SCIENCES. We will also need more care-

ful selection of new faculty members who will lead our institutions in the long term evolution of engineering education. If we recognize a shortage of science background in engineers today, one obvious aid is to pick faculty members whose training has emphasized the scientific approach to the solution of engineering problems. The result should be to strengthen the more scientific side of the engineering profession without loss in continuity of those magnificent contributions that the art of engineering has produced.

College Notes

A joint program in engineering and liberal arts between **New York University** and **Rollins College**, Winter Park, Florida, was announced by Dean Thorndike Saville of NYU's College of Engineering and President Hugh F. McKean of Rollins College. Under the arrangement, Rollins College students may, after three years, transfer to the NYU College of Engineering as juniors. On completion of the combined five-year program, they will receive the degree of bachelor of engineering in a particular branch of engineering from NYU. Meanwhile, Rollins will award the bachelor of science degree after the fourth year.

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A two-week special summer program on Mathematical Problems of Communication Theory will be presented at the **Massachusetts Institute of Technology** from July 12, through July 16, 1954. Further information and application blanks may be obtained from the Summer Session Office, Room 7–103, M.I.T., Cambridge 39, Massachusetts.

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Robert F. Bacher, Chairman of the Division of Physics, Mathematics and Astronomy at the **California Institute of Technology**, has been named acting dean of the faculty.

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Ralph B. Wiley, distinguished member of the **Purdue University** faculty for 46 years, head of the School of Civil Engineering and Engineering Mechanics since 1937 and director of the Joint Highway Research Project since 1939, retired June 30. He will be succeeded by Kenneth B. Woods.

Report of Summer Institute Preliminary Conference on Nuclear Physics in Engineering Education

By R. W. HOUSTON, *Editor*

Asst. Prof. of Chem. Eng., Columbia University

The Summer Institute conferences on Nuclear Physics in Engineering Education are sponsored by the ASEE jointly with the American Institute of Physics and the National Science Foundation. For preliminary orientation prior to the open conference to be held at Northwestern University in September, a closed conference was held at Columbia University from April 22-24, 1954. To this conference came over 30 * engineers and physicists from industry, the national laboratories, and the universities to discuss the requirements of atomic and nuclear science in engineering education and the means for its introduction. That such a group should devote its time and effort to this topic bears witness to the values to be gained by close cooperation among physicists and engineers.†

Objectives

At the outset of the conference it was recognized that one aim was to emphasize that modern engineering education must build upon a firm scientific base. This thesis is, of course, sparked by the fact that much of modern technology has been built upon scientific and technological foundations rather than chance uninformed invention, and there is every reason to believe that this tendency will continue. Today nuclear technology looms as a factor of tremendous potential importance in engineering. From the industrial point of view, atomic energy now means largely power or potential power. It was thus inevitable that the discussion tended toward this area of activity. However, other areas of potential industrial interest in the atomic energy field were noted, such as "by-product" radiation to catalyze chemical reactions.

The desirability of including nuclear physics in engineering education was discussed from the viewpoint of engineers and employers of engineers engaged in various atomic energy activities. The requirements of non-atomic energy industries were not specifically analyzed, although such industries were not wholly without representation.

This discussion raised two immediate questions: (a) What is meant by nuclear physics?, and (b) For what kind of engineer is the evaluation to be made? It did not appear necessary for the conference to come to any formal conclusions on these issues. However, the discussion broadened out to include not only physics of the nucleus, but also those areas of modern physics which are and will continue to be pertinent to the engineering development of atomic energy. The conference took cognizance of the fact that much of nuclear reactor engineering, for example, is actually rooted in the field of atomic rather than nuclear physics.

There are several facets to the second

* A list of those in attendance is appended.

† Cf. R. J. Seeger, J.A.S.E.E. *44*, 285, 385; N. W. Dougherty, ibid., 401.

question. The discussion was limited largely to education at the undergraduate level, recognizing that some 80 per cent of engineering students do not pursue formal education beyond the baccalaureate, but that the balance who enter graduate work in engineering is and should be slowly increasing. This trend would undoubtedly be accentuated by an early exposure to the analytical and the research point of view as developed in modern physics. It was also recognized that in addition to the traditional engineering disciplines, the curricula known as engineering physics or engineering science should be kept in mind, as well as a curriculum in what has been called nuclear engineering. The formal conclusions adopted by the conference and stated at the end of this report, avoid reference to specific areas of engineering.

In making recommendations as to the means for introducing "nuclear physics" into engineering curricula, it was recognized that it is both impractical and undesirable to suggest that engineering schools conform to any arbitrary pattern. The conference restricted itself insofar as possible to the questions of content and level, concluding that local situations in each school dictate the actual courses and their sequence.

The Employer's Problems

With regard to the number and distribution of engineers needed in atomic energy work three facts should be borne in mind: (1) Companies whose normal manufacturing operations require predominantly one kind of engineer would be expected to have a proportionately high percentage of this type in their atomic energy division. This reflects the fact that the engineering disciplines do frequently overlap one another. (2) The type of reactor being considered, designed, or operated may have considerable bearing on the type of engineer best suited to work on it. For example chemical engineers predominate at Oak Ridge, and the homogeneous reactors there being developed are considered primarily a chemical engineering problem. (3) A large proportion of any nuclear power plant capital investment will be in power generation and distribution equipment of more or less conventional design. This will always require the services of "conventional" power engineers.

As an example, the Atomic Energy Division of Babcock and Wilcox was reported to have the following composition:

Mechanical engineers	28
Electrical engineers	3
Nuclear engineers	8
Physicists	3
Metallurgists	4
Marine engineer	1
Management engineer	1
Total	48

This group is actively engaged in work leading to the construction of an economical nuclear power plant. As used here, the term nuclear engineer signifies a man with a better than average background in mathematics, atomic and nuclear physics, and who has completed graduate work at the Master's level, or equivalent, with specialization in the field of nuclear technology as typified by that given at the Oak Ridge School of Reactor Technology.

This same firm estimates that their atomic energy division will double its size in two to three years on the assumptions that nuclear power will be economically competitive with conventional power sources in the United States within ten years (except in the natural gas belt), and that the Atomic Energy Act will be modified to justify private capital risk within one year. The distribution of engineers would remain about the same with the exception of adding about four chemical engineers and two civil engineers. On this basis, it was estimated that as many as 6000 new engineers would be needed in this country by the nuclear power industry as a whole in about five years time. The opinion of the other conferees, however, was that this figure represents an approximate upper limit and that the

probable rate of growth may prove to be somewhat less.

A more fundamental approach to the required distribution of disciplines is to consider the nature of the work carried out by engineers in the development of nuclear power. Engineering problems relating to reactor core size, quantity and kind of fissionable material, and shielding, for example, must be handled largely by theoretical physicists or engineers with a strong theoretical background. Problems relating to physical characteristics of materials at high temperature or subjected to high radiation fluxes may fall chiefly to the metallurgist. The selection of materials with an eye toward neutron economy is of interest to both of the preceding groups. The metallurgist may also be faced with problems in corrosion of solid fuel elements and structural materials. Both chemical and mechanical engineers may be called upon to deal with this problem, not only in the reactor proper, but also in associated heat transfer and chemical processing equipment. Engineering problems in the design of control rod mechanisms, fuel handling facilities, and remote control devices must be handled largely by mechanical engineers. Problems in removing the heat generated in the reactor may be handled by both mechanical and chemical engineers. Sound structural design may be the responsibility of civil or mechanical engineers. Electronics engineers are required for control and instrumentation problems while electrical engineers must be concerned with the ultimate generation and distribution of electrical power. Associated with any nuclear power plant will be a fuel separation facility which will largely be the province of the chemical engineer. Cutting across all these specialties will be the continuing need for research and development-minded engineers and what might be called engineering economists who maintain constant vigilance for better and less costly methods.

A representative from Oak Ridge stressed the fact that, although the divisional structure of the laboratory followed the usual scientific and engineering breakdown, i.e., chemistry, physics, metallurgy, chemical engineering, etc., the work is actually conducted projectwise. In this way, each man on the project contributes most effectively when he comprehends all the scientific and engineering problems related to his own specific work. In other words, liaison among divisions is essential at all levels and not just at the upper supervisory levels. It is difficult to avoid the conclusion here that such engineering teamwork must be benefited by a common educational experience in basic science taught from the research point of view.

Nuclear Physics Requirement

A representative of the General Electric Company emphasized that 85–90 per cent of the engineers actually engaged in reactor and reactor component design require only a descriptive knowledge of nuclear concepts, i.e., familiarity with the language and ability to use the numerical values required in their phase of the work. This group should know the elementary particles and their approximate masses, but not necessarily their quantum or wave mechanical properties. The meaning of cross section and variation of cross section with energy and temperature should be qualitatively clear. Such terms as isotopes, radioactivity, activation analysis, neutron chain reaction, fission process, neutron diffusion, neutron flux, criticality, and transients should have a clear cut meaning to this group, although the ability to carry out extensive quantitative calculations on these subjects is not required. This list, of course, is much abbreviated, but it is evident that such topics as relate to the theory of nuclear structure and nuclear reactions are not required by the engineers in this group.

Only 10–15 per cent of the engineers engaged in reactor design and development work require a quantitative working knowledge of atomic, nuclear, and reactor physics, so as to be able to derive the pertinent numerical values. These have

been called nuclear analysis specialists. They must be able to organize, supervise, and interpret the detailed calculations involved in reactor design and the experimental testing required to bring a project to fruition. It might be expected that the majority of ideas for basic improvements in reactors would stem from this group. The educational background of this group would generally include graduate level work.

The conference did not attempt to reach unanimous agreement on the employers' needs with regard to nuclear physics in engineering training, but substantial accord was apparent on the following points:

(1) The majority of engineers employed in the nuclear field do not require a detailed knowledge of nuclear science, but a qualitative knowledge is essential.

(2) Specialization in nuclear engineering problems as another major engineering discipline is not warranted at the undergraduate level. There is, however, no reason why one or two term courses in nuclear theory and engineering problems should not be made available to undergraduate engineers on an elective basis at some schools. More importantly, many problem examples in standard undergraduate engineering courses can well be taken from the nuclear field.

(3) The most important requirements of any engineer in the nuclear field are his knowledge of fundamental concepts and his ability to think both analytically and creatively, since the technology of this field is diverse and subject to rapid obsolescence.

The Educators' Problems

The third principle objective of the conference, the *means* of introducing nuclear science into engineering curricula, is primarily of concern to the educators. The means may be discussed in terms of curricula and course content. The conference deemed the latter its major problem and did not attempt to make specific suggestions with reference to specific curricula. It recognized, however, the existence, or potential existence, of curricula in the traditional disciplines, as well as in engineering physics (or science) and nuclear engineering. All of these usually have a common core of basic science and engineering subjects, most of which are included in the Freshman and Sophomore years, plus the opportunity for a small amount of elective work in the upperclass years.

The conference did *not* recommend that any material now normally covered in a general physics or chemistry course be deleted or removed to a later engineering course. It did recognize that many aspects of modern physics can be successfully interwoven with the subject matter of classical physics, and that a close correlation with the general chemistry course is undoubtedly necessary for a satisfactory solution to this problem. In some institutions, if the formal conclusion recommending an advanced course in modern physics is adopted, it would mean that some other course or courses may have to be revised or dropped, or electives removed. The conference did not presume to suggest what can be done in this situation, feeling that it was entirely a matter for the particular school to decide.

Introduction to Modern Physics

The subject matter of modern physics may be introduced in the engineering curricula in two places, the Freshman-Sophomore general physics course, and/or a special course in the Junior or Senior year. Summarized below are the recommendations of one of the educators present on the introduction of modern physics into the general physics course.

The general physics course is perhaps best placed when it is preceded by a sufficient amount of chemistry to make it easy to introduce the atom and its structure early in the course. It should also be preceded by a sufficient amount of mathematics that calculus may be employed. (A minority of those at the conference felt that this was not essential.) In me-

chanics, the traditional starting topic, molecules should be introduced in connection with elasticity. The Bohr Theory of the hydrogen atom can be one of the examples of the inverse square law of force. Intermolecular potentials can be introduced in connection with surface tension.

Kinetic Theory should be emphasized. (Most members of the conference were in strong agreement on this point.) This brings to the student's attention the statistical approach. The application of kinetic theory need not be restricted to the ideal gas development, but, through the concept of mean free path, should be applied to transport phenomena, the behavior of neutrons in moderators, electrons in metals, high vacuum production, etc.

The electron should be introduced at once in electricity. Emphasis can be on the Van de Graaff generator, the motion of charged particles in electric fields, and Millikan's oil drop experiment. The action of magnetic forces on currents and moving charges can include discussion of the mass spectrometer, at which point isotopes can be introduced, the cyclotron, and the synchrotron. Faraday's law of electromagnetic induction can be illustrated by the betatron. Limitations on the attainment of high voltages by transformer action can be brought out at this point.

In close association with the subject of electronics, in which scalers as well as amplifiers, rectifiers, etc., can be discussed, is the subject of quantum theory, the elements of which can be illustrated by photo and photo-multiplier tubes, X-ray production, and Geiger-Mueller counters. Use of the Bohr Theory to illustrate ionization potentials and the production of spectral frequencies can be an important means of introducing the concepts of nuclear structure.

Near the conclusion of such a course, the elementary particles, protons, neutrons, etc., can be further discussed, along with nuclear forces, mesons, radioactivity, fission, the mass-energy relation, and the principles of relativity, especially the increase of mass with velocity.

Demonstration of experiments should accompany the lectures, preferably using standard components but with large schematic diagrams for illustration. Laboratory experiments might include scintillation counting in a darkened room, measurement of radioactive half-life, neutron intensity about a paraffin moderated neutron source, and beta absorption measurements.

The conference recognized that there is a limit to the extent to which modern physics can be introduced into a basic general physics course and for this reason made the third recommendation given at the conclusion of this report. The level at which this material should be presented requires the use of calculus. The conference also noted that, where appropriate, approximate graphical and numerical mathematical procedures should be employed and the availability and use of automatic computing machines in making scientific calculations might reasonably be discussed. Close cooperation among the teachers of mathematics and physics, as well as engineering, thus is indicated.

Perhaps the strongest recommendation of the conference relates to the inclusion of atomic energy material into standard engineering courses. It was stressed, in particular by the engineers and physicists in industry and the national laboratories, that nuclear technology is closely related to almost every one of the conventional engineering disciplines and that adequate preparation in the fundamental concepts and methods of analysis in these fields is essential preparation for nuclear engineering. Many engineering problems can be drawn from the nuclear engineering field. For example, an engineer is better equipped to solve heat transfer problems in reactor design if he is familiar with the broad range of heat transfer applications in industry, than if he has simply been trained on the heat transfer problems in reactors. There are many reactor heat transfer problems which could easily be used as problem examples in the general field of heat transfer in undergraduate me-

chanical or chemical engineering courses. The effects of radiation on solids fits in quite properly in courses in metallurgy and engineering materials of construction. Remote handling equipment design problems might be included in mechanical engineering design courses. Chemical processing of radioactive and fissionable materials and isotope separation processes should furnish additional problem material in chemical engineering courses, covering the general problems of industrial-scale physical and chemical separations. Electronics instrumentation courses can show that similar principles apply to the design of instruments to monitor radiation and to control reactors as apply in the communications industry and in the new forms of industrial electronics.

This principle can be applied to both graduate and undergraduate engineering courses, although it may be possible to carry it a little farther on the graduate level. For example, a chemical engineering course in applied reaction kinetics might reasonably devote one or two weeks to nuclear chain reactions, the basic approach to the nuclear reactor design being essentially similar to chemical reactor design.

Availability of Nuclear Information

There are two important questions involved in carrying out this recommendation, viz. (1) the potential problem of security and classified information, and (2) the problem of engineering educators themselves becoming sufficiently well versed in the nuclear field to introduce examples taken from it. The majority of the conferees saw no real problem in security. A great deal of important information on methods and data has been declassified and published either in regular journals or as government documents that are readily and economically available. It was also suggested that if engineering educators show a greater interest in obtaining information for use in course work, it is possible that some of it might be classified more quickly.

The second problem, that of getting the information to the teachers themselves, is of more significance. This problem is not as important in institutions having staff members who have worked in the atomic energy field or who are engaged as consultants therein. For others, a few texts are now available, or will be in the near future.‡ Teachers wishing a more direct picture of the field may be able to obtain summer employment in one of the atomic energy installations, or admission to the one year course at the Oak Ridge School of Reactor Technology.§

The conference did not attempt to come to a definitive conclusion regarding specific courses, nor the content of courses in nuclear engineering and technology. Some members of the conference felt that it was highly desirable to have one or two-term courses available to upperclass engineering students on an elective basis. Others felt that a better alternative was the advanced course in modern physics mentioned earlier. No one expressed the view that nuclear engineering should be a discipline alongside mechanical, electrical, chemical engineering, etc. Most agreed that it was not inappropriate for some institutions to offer at least the possibility of a strong minor in nuclear engineering at the graduate level. The availability of appropriate staff personnel and laboratory facilities must dictate the solution at specific schools, of course, with an eye to the present and future needs of the industry.

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‡ For example, see: Glasstone, S. & M. C. Edlund, "Elements of Nuclear Reactor Theory," D. Van Nostrand, N. Y., 1952; Stephenson, R., "Introduction to Nuclear Engineering," McGraw-Hill, N. Y., 1954; Bonilla, C. F., ed., "Nuclear Engineering," McGraw-Hill, N. Y. (to be published); Goodman, C., ed., "The Science and Engineering of Nuclear Power," Vols. I & II, Addison-Wesley (1947); Murray, R. L., "Introduction to Nuclear Engineering," Prentice-Hall, N. Y. (1954).

§ For information, write to ORSORT, Box P, Oak Ridge, Tenn.

Conclusions

The following formal conclusions and recommendations of the conference were adopted without dissent at the final session on April 24, 1954.

"In view of the increasing role of atomic and nuclear phenomena in engineering, it is the sense of this conference that:

1. All *general physics courses* should give continual attention to the inclusion of modern physics material at appropriate places throughout the entire course.

2. All *engineering courses* should give continual and increasing attention to the inclusion of pertinent atomic energy material.

3. All *engineering curricula* should contain atomic and nuclear science material of a scope covered by a 3 semester-hour course at the junior or senior level (beyond general physics) including topics such as:

(1) Atomic Structure of Matter
  (a) Kinetic Theory
(2) Fundamental Particles
(3) Quantum Theory of Light
(4) Atomic Structure
  (a) Energy Levels
  (b) Spectroscopy
  (c) Periodic System
(5) X-Rays
(6) Wave Nature of Matter
  (a) One Dimensional Wave Equation
(7) Atomic Nucleus
(8) Molecular Structure
  (a) Valence Bonds
(9) Nuclear Structure—Elements, isotopes, elementary particles
(10) Binding Forces
(11) Binding Energy Curve
  (a) Mass-Energy Relation
  (b) Radioactivity
  (c) Nuclear Reactions
  (d) Fission, Fusion
(12) Neutron Chain Reaction
  (a) Heat—Power
  (b) Radiation—Interaction with matter
    Radioisotopes
    Breeding
  (c) Fission Products

4. In view of the rapid advance of this new field it is also the sense of this conference that all *engineering schools* should give continual attention to the possibility and need for professional education in nuclear technology, especially at the graduate level.

The conference recognizes that the realization of these objectives will vary with local situations. It is evident, however, by the very nature of atomic energy that their implementation can be achieved only through close cooperation of engineering and physics departments, as well as other science departments."

Conference Members

Clifford K. Beck, North Carolina State College
Clarence E. Bennett, University of Maine
Charles F. Bonilla, Columbia University (Chairman)
Lyle B. Borst, University of Utah
Joseph C. Boyce, Argonne National Laboratory
William M. Breazeale, Pennsylvania State College
Arthur B. Bronwell, Northwestern University (ASEE Liaison)
Harvey Brooks, Harvard University
George M. Brown, Northwestern University (Open Conference Chairman)
Robert A. Charpie, Oak Ridge National Laboratory
William H. Crew, Los Alamos Scientific Laboratory
Thomas B. Drew, Columbia University
John R. Dunning, Columbia University
Russell A. Fisher, Northwestern University
Henry J. Gomberg, University of Michigan
B. R. Gossick, Purdue University
John J. Grebe, Dow Chemical Company

William W. Havens, Columbia University (Co-Chairman)
R. Wayne Houston, Columbia University (Editor)
E. N. Jensen, Iowa State College
John W. Landis, Babcock & Wilcox Company
Donald H. Loughridge, Northwestern University
Ralph A. Morgen, National Science Foundation (NSF Liaison)
Raymond L. Murray, North Carolina State College
V. L. Parsegian, New York Office, A.E.C.
William G. Pollard, Oak Ridge Institute of Nuclear Studies
Monty A. Schultz, Westinghouse Atomic Power Division
Raymond J. Seeger, National Science Foundation
Thoma M. Snyder, Knolls Atomic Power Laboratory
Richard Stephenson, Oak Ridge National Laboratory
William W. Watson, Yale University (AIP Liaison)
Martin D. Whitaker, Lehigh University
Clarke Williams, Brookhaven National Laboratory
Hugh C. Wolfe, Cooper Union
Frederick C. VonderLage, Oak Ridge National Laboratory
H. A. Wagner, Detroit Edison Company

Sections and Branches

A meeting of the North Midwest Section of the American Society for Engineering Education was held at Marquette University, Milwaukee, Wisconsin, October 10, 1953. Report of the Nominating Committee was presented and unanimously approved.

Chairman Drought reminded all division chairmen as well as all chairmen of committees to submit a written report on their committees and meetings to the chairman of the section for inclusion in his report.

Dean Kurt Wendt reported on the past year's activities of the national executive council including discussion of the following items:

1. The concern of the national council for the efforts of some groups toward the "unionization" of engineers and, in some cases, the establishment of student chapters of unions on campus.
2. The attitude of the national council toward the presence of commercial displays at the national conferences.
3. The unanimously granted honorary memberships of Dean H. P. Hammond and Dean A. A. Potter.
4. The proposal for an increase in members' dues which will be sought by individual ballot in the future.
5. The proposed joint venture on the part of the Relations With Industry Division and the ECAC Committee on Selection and Guidance to study the possible prediction of success of engineers.
6. A thorough discussion of the "First Resolution on Accreditation Adopted by the Committee on Evaluation of Engineering Education."

Industrial Summer Opportunities

By CLYDE E. WORK

Associate Professor of Mechanics, Rensselaer Polytechnic Institute

and HAROLD P. SKAMSER

Chairman of Engineering Placement, Michigan State College

It is widely recognized today that the most effective engineering teacher cannot be developed and nourished on book knowledge and contemplation alone. Direct first hand activities in the industries in which his students are to be engaged offer a means of broadening his professional perspectives for both teaching and counseling.

There is only one practical way for the college faculty member to get this viewpoint reliably, that is to work for several companies in each of several industries. Ideally, he will have worked in different departments of different companies and each of these engagements will be of sufficient duration to enable him to acquire a feeling for the operation; i.e. an understanding of what was going on, both in the technical operations of the company as well as in what can be called the psychological or personnel-management side. Obviously, any approach, no matter how remote, to such an achievement would require exceptional cooperation and understanding in the industry making the opportunities available to large numbers of the college educational staffs of the country.

Although no such goal has yet been reached, some far sighted industrial leaders have taken the initiative to do more than their share in this effort. Their conscious efforts have been in the direction of offering short term employment, of men in the teaching profession, in their own industries or inviting educators to participate in joint conferences, seminars and discussions of mutual problems at the expense of the host industry. Some such programs are on a leave of absence basis but those available to the largest per cent of the professors are offered during the summer vacation period.

Some of the opportunities which summer employment in industry can make available were discussed by the authors in a previous article.[1]

It is the purpose of this article to describe what some other industrial groups are doing in the same general effort. It is recognized that the programs included here are not the only ones, but it is felt that they are representative of the best of today's opportunities in this area.

General Electric Company

Professors Conference: This program was initiated in 1937 and each summer approximately twenty-five engineering educators from all over the country, ranking from instructors to deans, are invited. Fields represented usually include mainly electrical and mechanical engineers with a few industrial engineers. The five week program includes three weeks during which time the visitors work on a specific assignment in one of the company's plants and a two week formal program of conferences,

[1] Summer Employment—Boeing Style, JOURNAL OF ENGINEERING EDUCATION, Vol. 44, No. 9, May, 1954.

seminars, lectures, tours, social activities and recreation. Many top level company personnel participate in presentations of various phases of the company's operations, discussions of opportunities for engineers within G.E., development of the engineer, evaluation of his performance and other pertinent topics.

Teaching Methods Seminar: This is a one week program sponsored jointly with the A.S.E.E. to which about twenty-five young engineering instructors with a wide variety of academic interests, and distributed over the nation, are invited to study in Schenectady the educational teaching techniques used in G.E.'s Advanced and Creative Engineering Programs and evaluate an application and the effectiveness for undergraduate academic teaching. Participants receive only expenses but in addition to planned technical sessions hold informal discussions, plant tours and limited social activities.

Informal Summer Employment: More than thirty engineering professors were employed on individual work assignments during the summer of 1953. The number any given summer depends on the specific projects lending themselves to short term assignments. In 1953, during the month of July, a technical lecture program consisting of a series of nine afternoon sessions of an hour and half each, were arranged for these men. Topics considered pertained to various phases of technical interest within the scope of the company's activities and were presented by G.E. personnel.

A few organized plant tours were arranged and individual tours could be requested. One or two minor social events were held in 1953 and it is hoped to extend this area in the future.

International Harvester Company

Program for University Faculty Members: A three week summer conference has been held annually since 1949 to which the company invites ten to twelve colleges to send faculty members representing specified departments. The purpose of the program is to acquaint educators with Harvester and its philosophy and to gain from the observations and opinions of the educators.

The first half of the program consists of conferences with top management and plant tours. During the second half, participants carry on individual study in the phase of operations related to their own field of interest. Visitors are invited to all regular sessions of the Executive Council, and committees of the company meeting during the conference period.

Informal Summer Employment: Opportunities for full summer employment on a specific project are on an individual basis depending on the needs developing in the various departments and plants.

E. I. DuPont de Nemours & Co.

Year in Industry Program: The company has developed a program offering a year in industry for three engineering educators each year. Men with academic administrative duties under the age of 55 are eligible for selection. The purpose of the program is to give the educators broad understanding of the DuPont Engineering Department, to aid industry through the students and to improve college-industry understanding.

Compensations equivalent to normal college earnings plus an allowance for travel are offered while the professors visit and study all divisions of the engineering department. Visitors discuss organization and management with top level management, operations with middle management and the problems of newly employed graduates with the graduate himself. They visit various plants under construction and in operation and have the opportunity to learn the details of any engineering job of particular interest from the man who does the job.

3-Week Symposium: The DuPont Company also conducts a symposium planned particularly for social scientists

in which executives discuss business philosophy and methods with guests. A series of plant tours are also arranged for participants.

Monsanto Chemical Company

Industrial Leave Program: The company invites a college faculty man, hitherto inexperienced in industry, to spend an academic year with them.

Summer Employment: A variety of assignments in departments of the company such as production and engineering develop for assignment to faculty members interested in summer placement. Efforts are being made to enlarge the scope of this program.

Bell Telephone System

Short Conferences: Bell sponsors short conferences for faculty members lasting a week or two on specific activities. In the summer of 1953, the Bell Laboratories had representatives from colleges all over the country, discussing new developments in computers. The Michigan Bell had a one week conference in August, 1953, on the economics of the utility.

Summer Employment: Western Electric, Bell Laboratories, Sandia and other divisions of American Telephone and Telegraph Company hire faculty members during the summer months for specific assignments. However, during these intervals the faculty members are given ample opportunity to visit other departments and talk to specialists in other fields. An executive with the Bell system indicates that they are aware of a need for a more formalized program of summer faculty employment.

Conclusions

The faculty members participating in industrial programs such as the ones described here are enthusiastic as to the benefits derived and the desirability of broadening the scope of opportunities available. Sponsoring companies express satisfaction and sense a need for continuation and expansion of programs of the types described.

A sub-committee of the YET group in ASEE has initiated a project to encourage participation of faculty men, particularly the younger ones, in these programs, to encourage other industries to establish such programs and to encourage companies already doing so, continually to reexamine and improve their plans so that through combined efforts and participation, the quality of the graduating engineer who is the end product of our schools and one of the raw materials for industry will continue to improve.

The authors do not recommend any uniform plan as an ideal program to be offered by all companies or claim that one type of program meets the need of all faculty members. It is, rather, encouraged that each industrial group begin or continue to experiment with ideas to fit their own situations but which will contribute to the overall success of those professionals charged with the responsibility of training the engineers of the future.

Engineering Curricula—Then and Now

By ELMER HUTCHISSON

Dean of the Faculty, Case Institute of Technology

The first reaction of an old grad when he sees the study program of the boys now in an engineering school is "Jeepers, I sure am glad I didn't have to study that stuff when I was in school—I never would have graduated!" Actually, however, present students don't find their studies any more difficult than did the students of twenty-five years ago. If we look back at the records we find that in many schools higher average grades are being given now; moreover, the work loads in terms of contact hours are considerably lighter. We must remember that our modern student has grown up in a world in which the vacuum tube, the mechanical brain and the jet plane are commonplace—so much so that an old-timer nowadays has a hard time even following the adventures of Dick Tracy or the other heroes of the "comic strips."

A comparison of a typical curriculum of today, such as that in mechanical engineering, with one of two or more decades ago, shows not only a new terminology associated with the atomic age but also a new philosophy. Engineering no longer needs to depend upon empirical data and empirical methods to the extent it did some years ago. We all remember our courses in applied mechanics where we would calculate stresses in a beam to three (or more!) significant figures with our slide rules and then multiply by a factor of four or five which our instructors called "a factor of safety" but we with more wisdom than we realized called "a factor of ignorance." We know now that few aeroplanes could get off the ground if we couldn't calculate stresses more precisely than we were able to in those days. In fact, because of our ever-increasing desire and need to use materials more efficiently in this competitive world, detailed stress analysis has, in spite of its complexity, become an important phase of any course in engineering mechanics.

This same trend toward more detailed mathematical analysis is taking place in other engineering fields such as fluid flow, thermodynamics, electrodynamics and even in production engineering where motions are timed to thousandths of a second. To some, the course work may seem to be growing constantly more complex but actually the opposite is happening since broad generalizations are being substituted for a mounting mass of observational data which would need to be included in our curriculum if we did not place our main emphasis on fundamental laws. We will return to this emphasis on fundamentals later, but it will be well to compare in Fig. 1 the combined amount of time devoted to fundamental science and engineering in the 1953–54 mechanical engineering curriculum at one par-

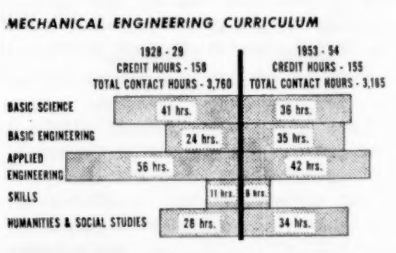

FIG. 1. Comparison of a typical mechanical engineering curriculum of 25 years ago with that of the present.

ticular college with that appearing in the 1928–29 curriculum.

Educational Problem

This brings us to an interesting educational problem—how do changes in college curricula occur? Of course, the main responsible body in most colleges is the Board of Trustees but the Board usually delegates all matters relating to the curriculum to the faculty. Minor changes in the curriculum are occurring regularly but often a complete revision of a curriculum is undertaken. On these occasions a rather small faculty group usually proposes a change and then after considerable study, consultation and debate the faculty formally adopts a new curriculum. The administrative staff of the college, as well as the faculty, has constantly to be on the alert to prevent any curriculum from becoming out-dated. To carry out this responsibility some guiding principles are needed that will enable one to judge which of two curricula is better.

Guiding principles in education cannot, unfortunately, be separated from one's personal philosophy of education. There have been numerous books lately by such eminent educators as James B. Conant and Robert M. Hutchins on the kind of higher education required in a free society. Fortunately, the problems in engineering education are much simpler than those in the liberal arts field, but this does not imply by any means that there are no problems.

For example, we like to ask ourselves, can we not design a perfect curriculum—if not perfect, at least, a better one than the one we had when we were in college? As we pursue this question further, another inevitably arises. For whom should the curriculum be better? Is it for the young man who pays his tuition? Or is it for society? The public-spirited men of the past who provided classrooms and laboratories and the endowment which continues to pay a substantial portion of the college operating costs, certainly were making their contributions to society generally rather than to the particular individuals who are admitted to the freshman class. The state itself makes a contribution by waiving all taxes. In addition industry is presently making a significant contribution to the operating expenses of many colleges.

All of this is as it should be. Society, like industry, finds it expedient to plow back into education a share of its profit as an investment for its future. In the early days society relied almost completely on education for the ministry. Later, education for the law and for medicine came in for a large share of the public interest and public funds. Only recently, with the clear dependence of our standard of living and even our national security upon advances in science and technology, a new interest in well-planned technological education has arisen.

Responsibility to Society

In planning a curriculum for an engineering college, perhaps the distinction just made as to whether our responsibility is to society or to the student loses its significance if we plan far enough ahead. For example, if we should design our curriculum so that our student can command maximum salary immediately upon graduation we should very likely come into conflict with our responsibility to society. On the other hand, if we aim at a curriculum which prepares a young man to be of maximum usefulness in a dynamic society throughout his life then there can be little doubt that he will receive adequate financial and other rewards from that society.

New questions arise in our minds. Can we recognize clearly the characteristics which we would like to see developed in our young man so that he will be useful in present-day society? Can we be sure also that these same characteristics will be valuable in the society which we will have some twenty to thirty years hence? If we can identify those characteristics which are likely to be useful, no matter how either our young man or society de-

velops, we will have a sound basis upon which to design the curriculum.

In seeking those characteristics which should be of value for all time in a dynamic society a few needed characteristics, upon which we will all agree, stand out. First, there are moral and ethical qualities—we must assist our young student to develop a high sense of personal integrity, a sense of kindliness, an ability to work with others and a confidence in himself which will enable him to assume leadership. Next, he must have a thorough knowledge in his technical field of those fundamentals which are themselves timeless and which have wide applicability. So that there may be time for these principles to be thoroughly learned in his undergraduate college years, specific applications to special processes must be left to later experience in industry or to graduate work. Also we expect any well-educated man to have a reasonable knowledge of history and the background of his own culture. Finally, and far from least, he must be able to communicate to others his ideas and his convictions and to receive theirs.

In analyzing those qualities which we want in each of our graduates, they seem to fall into two main categories. There are those which are taught by regular classroom and laboratory methods and those which, in this sense of teaching, cannot be taught at all. For example, one can't teach integrity or leadership by classroom methods and yet we all agree that these qualities are of utmost importance. Usually we separate out those subjects which can be taught and organize them into a formal sequence and this is what we call the curriculum. Progress in curricular subjects is measured at regular intervals and generally is the sole criterion for scholastic advancement.

How can we measure progress in the less tangible but ever so important characteristics such as integrity, kindliness and the ability to lead? Unfortunately, we have no way of making precise measurements but the faculty can and is definitely expected to do much to develop these qualities by setting examples to the students both inside and outside the classroom. Further, there have been set up what are called the extra-curricular or co-curricular activity programs which are in essence laboratories for developing human relations. It is just as important that the extra-curricular program be organized to carry out our fundamental educational goals as it is for our curricular program. This, however, is another story and in spite of its great interest we will restrict ourselves here to the academic course structure which we called the curriculum.

Two Kinds of Knowledge

In considering those subjects which make up the curriculum, we find that there are two essentially different kinds of knowledge each of which has its own teaching methods. The first of these includes such subjects as mathematics, the natural sciences, basic engineering and parts of history. This knowledge is generally called accumulative. The second kind of knowledge includes such subjects as politics, art, music and other areas closely tied in which human relations. These subjects have been designated as non-accumulative, although in many respects this is a misnomer. Dr. Conant, the former president of Harvard University, has suggested a test for distinguishing between accumulative and non-accumulative knowledge. Essentially his suggestion is that those subjects for which there exists reasonably uniform agreement as to what constitutes progress are called accumulative. Parenthetically, in these areas there exist also criteria for discarding obsolete knowledge. Such a field as mechanics certainly meets this test where all would agree that Newton's work represented progress over Galileo's and that Einstein's theories represent an advance beyond Newton's.

A prime example, on the other hand, of the non-accumulative field is that of art where there seems to be no agreement that Picasso or other modern artists have ad-

vanced beyond Michelangelo. Likewise, can there be any agreement that modern music represents progress as compared with so-called classical music or that we made much progress in our knowledge of how to prevent war? In fields such as these our stockpile of knowledge has been constantly building up over the centuries because we have no way of knowing which material can be discarded and which must be kept. We have accumulated less certainty but an awful lot of uncertainty. This makes the task of selecting material and teaching in these areas especially difficult.

Non-accumulative Knowledge and the Case Method

Let us now consider the procedures which seem to be most effective in teaching non-accumulative subject matter. An educational example in which there has been much experimentation is that of teaching decision-making in courses of business management. What one would like to do in such a course is to provide, within a limited period of a few months, the variety of experiences which one might get in many years of business. To do this one prepares a sequence of "case histories" which describe in considerable detail situations which have occurred in business. All of the facts and personalities involved are included and the case is presented to the class for extensive discussion and each member of the class is expected to make an appropriate decision and in some cases expected to justify his decision to the class. Through this case method, the student acquires vicariously in a relatively short time experience which he could only get in actual practice over a number of years. The case method has been given extensive trial at the Harvard School of Business Administration.

The case method undoubtedly has wide applicability in an academic curriculum and needs to be further developed. It is the one opportunity that we have of compacting the subject matter in non-accumulative areas of knowledge and thus making our teaching more effective. Some schools are presently using this method in courses such as surveys of American democracy and of western civilization. In these courses the instructors attempt to engender in the student strong convictions about the society in which he is living and his responsibilities in preserving our freedoms. Another area in which the case method is being given a thorough trial is that of machine design. Recently a week's conference was sponsored by industry to explore improvements in machine design teaching which are possible by the more extensive use of the case method or as it was called in this conference the project method.

The perfection of the case method of teaching and a recognition of its advantages in some areas of learning and its limitations in others are rather recent educational developments. It is a powerful teaching tool which has a definite place in our educational curricula and accounts for some of the changes which have occurred in engineering curricula in the past two decades.

Let us now look at the other broad area of knowledge that goes into our curriculum, that which we have called accumulative. Are there general principles that will enable us to improve the effectiveness of our teaching in this area? Are there also ways in which our curriculum should be modified so that engineering graduates will continue over the next twenty to thirty years to take the leading role in industry and in the community that they have in the past?

At least one answer to the first question appears from a closer examination of the nature of accumulative knowledge such as mathematics, mechanics, thermodynamics, etc. As implied earlier, an outstanding characteristic of these subjects is that they have been greatly compacted through the elimination of obsolete subject matter and through broad generalizations so that a college sophomore today can learn in one year to solve problems in mathematics or in mechanics that would have stumped

even Newton in his lifetime. In this compacting there has occurred an ordering process such that the more simple parts of the subject can be identified and learned first. In building a curriculum, advantage can be taken of this characteristic by a more systematic arrangement of the subject matter within a course and by the logical combination of the individual courses. Obviously, the student should not be permitted to advance to more complex material until the early parts are mastered. This condition is relatively easy to fulfill for the accumulative subject matter because understanding can often be tested by the student's ability to solve problems which have solutions which are definitely right or definitely wrong. Unfortunately, the same is not always the case with subjects in the non-accumulative field.

Accumulative Knowledge

The bulk of the purely technical subject matter taught in an engineering school is of the accumulative type. It is for this reason that so much emphasis is placed on mathematics, physics and chemistry in the student's first year. Throughout his four years the student builds upon these fundamentals. He cannot possibly learn special applications in this short time so that if he is to continue to be able to grow after college, he needs to be unusually well-grounded in these basic areas. The fact that engineering is constantly becoming more analytical means that the emphasis on basic science and basic engineering must be continually increased. This is borne out, as was mentioned earlier, in the comparison of the 1928–29 and 1953–54 curricula in mechanical engineering. It will be even more apparent if one visits a modern mechanical engineering laboratory and sees the maze of vacuum tubes, electronic circuits and precise measuring equipment which is becoming part of the engineer's stock in trade.

The fact that so much of the subject matter of engineering is accumulative explains the difference in the number of electives in the engineering curriculum as compared with that of a liberal arts college. When one is studying primarily non-accumulative subject matter it does not make very much difference whether one subject or another comes first since one subject does not as a rule build upon another. Also because of a lack of compacting, such as occurs in science or engineering, there is tremendous variety of subject matter to choose from. Since no one can say that one subject is more important than another, the choice is left to the student. Just the opposite occurs in engineering. If one decides to select a given branch of mechanical engineering, each course fits into a pattern which leads the student from the simple to the complex over a four-year period and very little can be left to the choice of the student.

Because time is so limited in the engineering curriculum, an attempt has been made in the teaching of the humanities and social studies in at least one engineering school to achieve some of the advantages which come from the compacting in the accumulative areas. The discussion method is used almost exclusively but great care is taken in the selection of the subjects for discussion and they are brought as far as possible into an orderly array within a four-year integrated program. This procedure gains ready acceptance among students used to the rigor and logic of engineering courses, and engineering schools have an unusually good opportunity of making a real contribution to teaching effectiveness in this area. The programs now underway are drawing national attention and support and may well be used as a pattern for the teaching of these subjects in other engineering schools and perhaps even in the liberal arts colleges.

The Art of Communicating Ideas

There is one further characteristic that we listed as being essential in a well-educated person. This is the ability to interchange ideas freely with other peo-

ple. We like to start our instruction by being sure that our student can read quickly and with full comprehension. In some schools, tests are given to the entering freshman and if he is a slow reader, he is sent to the reading laboratory where with the aid of optical-mechanical devices he is taught to increase his reading speed sometimes as much as two or three times what it was originally. Next he is given instruction in clear, concise and effective writing. Later he is given training in oral expression, not only in debating but in the simple natural use of one's speaking ability to get ideas across to individuals or to groups. The engineering student is taught principles which he will have ample opportunity to test and apply throughout his four years in college and, in fact, throughout his entire professional life. One additional tool of effective expression is often developed in the engineering curriculum. This is the use of the graphic arts to assist in the communication of ideas. No longer can an engineer be satisfied with the use of blue prints to get his ideas across. Instead he must be able to write clearly, speak forcefully and use all manner of charts, sketches, diagrams and pictures to sell his ideas to others.

Summary

Thus we see some of the differences in the curriculum twenty-five years ago and today. The present curriculum is more concentrated with greater emphasis on fundamentals both in science and in engineering. The curriculum is broadened by the inclusion of carefully tailored overall programs in the humanities and social studies and by placing great stress on the development of the ability of communicating ideas effectively to others. Sight is not lost of those invaluable qualities of personal integrity, kindliness and leadership and a determined effort is made to develop these throughout the entire curricular and extra-curricular program. The perfect curriculum is still a dream but there is a growing conviction that a good broad technological education is the best general education that society can offer.

Opportunities for the Civil Engineer in the Atomic Energy Industry and the Resultant Challenge*

By E. F. GLOYNA

Associate Professor of Civil Engineering, The University of Texas

A prominant engineer in the atomic energy industry has said, "The Civil Engineering Profession in general and Sanitary Engineering in particular should be much more active in the new atomic energy industry both in obtaining a proper evaluation of their interests and in appraising their opportunities and obligations."[1] His statement might further imply that the development of the atomic era is dependent upon the combined efforts of all professions; for each professional group has its obligations in the productive peace-time development of atomic energy. Those professions which fail to evaluate their obligations can expect the opportunities to be absorbed by the more informed and energetic organizations. Engineers therefore should re-evaluate their educational and professional status with regard to this new development.

Civil Engineers are potentially capable of contributing much to this combined scientific and technical endeavor, and are particularly needed in matters involving:

1. Selection of plant sites for nuclear reactors and associated units.
2. Design and construction of special structures and facilities.
3. Research in all phases of civil engineering.
4. Development dealing with water purification, waste disposal and environmental sanitation.

The opportunities for civil engineers in the atomic industry are real; but only those engineers who broaden their knowledge to include these modern scientific developments may actually benefit. Accordingly, civil engineers should have a fairly complete understanding of the basic sciences, particularly introductory nuclear physics. The reasons for and methods by which the civil engineers may keep abreast of modern developments can best be exemplified by expanding upon the four major endeavors stated in which the civil engineer may be used.

Site Selection

The first opportunity for contact between civil engineers and the atomic energy industry is in plant site selection. The choice of nuclear reactor sites is really a cooperative venture between management, engineers, geologists, stream biologists, meteorologists, health physicists and defense personnel. Because of possible surface, ground water and atmospheric contamination by radioactive isotopes, the geologists, meteorologists and stream biologists are key members of the site selection team. The health

* Paper presented to the Student Section, American Society of Civil Engineers, The University of Texas, August, 1953.

[1] Gorman, A., "Learning to Live with Atomic Radiation—A Challenge to Engineering Profession," *Civil Engr.*, **824**, 28 (Dec. 1949).

physicist and disaster-defense team may also exercise considerable control over the actual selection because of the necessity of area-radiation hazard control. The desirability of broader knowledge on the part of civil engineers is further emphasized by the fact that the usual yardsticks of water, fuel, transportation and labor resources are not the only criteria for the judicious location of atomic power units. In this connection, appropriate professional decisions may be made by combined interests if each group concerned draws from a reservoir of common but basic scientific knowledge.

Design and Construction

Many civil engineers are employed by the Atomic Energy Commission (A.E.C.) in conventional capacities. The number of civil engineers required is necessarily large since the A.E.C. projects are tremendous as compared with the average endeavors of industry. The cost of the original Oak Ridge establishment, plus the city of Oak Ridge, was over one billion dollars. One of the newer gaseous diffusion units at Oak Ridge cost over one-half billion dollars; and to operate these units the world's largest steam-generating, electric power plant had to be constructed. The need for this additional power, even though Oak Ridge is in the midst of the Giant Tennessee Valley Authority, illustrates the immensity of the atomic energy projects.

In addition to the conventional problems in design and construction, new problems have been introduced by nuclear reactors and allied facilities. Never before has the engineer been called upon to design radiation protective devices that permit the handling of thousands of curies. (Until the atomic era came into existance only a few curies of radium were available to industry.) Some of the essential protective measures are attainable through the use of specially prepared dense-concrete, or through the use of pneumatically operated tunnels or water-filled canals. These tunnels and canals are vital in facilitating the transporting of "hot" radioactive batches. Another example of the necessity of special design is demonstrated by the inadequacy of ordinary designed centrifugal pumps and electric motors. The commonly used packing and insulation become inoperative when centrifugal pumps and electric motors are subjected to neutron bombardment. Furthermore, once this equipment has been subjected to high levels of radiation, remote control measures must be available to facilitate repair.

These special features and many others too numerous to list are sufficient reason for the engineer to expand his fundamental knowledge of materials through research.

Research

From the few illustrations which have been given it is evident that the engineer has more than just a fleeting responsibility in the field of basic research. To emphasize this challenge, reference need only be made to a policy statement of the National Manpower Council, "That there is now a shortage of physicists with all levels of training to assist in translating new scientific developments into the field of engineering. This shortage can best be relieved by providing additional mathematical and basic scientific training for engineers." [2]

Several Atomic Energy Commission installations have sanitary engineers to direct the research and actual disposal of liquid wastes. In these installations the sanitary engineers have maintained close contact with the physicists, radio-chemists and stream biologists. Although much credit is due the sanitary engineers who have undertaken some of the basic research, much more research and work should be carried out before the techniques and efficiencies measured in terms

[2] "A Policy for Scientific and Professional Manpower," prepared by the Research Staff of the National Manpower Council, New York; Columbia University Press (1953).

of activity removal and costs can be definitely determined.

Water Treatment, Waste Disposal and Environmental Sanitation

Process water, used water and its associated health implications in the nuclear industry are of such importance that the future of atomic energy in commercial industry may well hinge upon the ability to handle the waste products economically.

In many respects, nuclear fission operations start as do many other industrial operations. Raw materials, primarily uranium ore, must be crushed, screened, refined and finally exposed to high level neutron bombardment. During this bombardment some of the uranium atoms split, resulting in the liberation of energy and formation of different radioactive elements. Some of this energy is released in the form of heat which is usually controlled by air or water. In either case the large quantities of coolants become contaminated and are potentially hazardous. The technical control required for the treatment of coolants must be of the highest order to reduce the degree of contamination.

Wastes from nuclear reactors include the usual liquid, dry and gaseous products. Dry wastes are canned and buried, while the finely divided particles in gaseous streams are separated from the fluids to the point where atmospheric dilution is possible. Liquid wastes are more of a problem. As an example of the potential hazard envolved, one gram of Sr^{89} (a product of uranium fission) in 100,000,000 gallons of water could cause the tolerance value for ingestion to be many times above the Maximum Permissible Allowable (MPA) tolerance value for liquid ingestion. MPA values are important guide posts; and frequently treatment, together with dilution, produces a resulting solution which is not harmful for human consumption.

On the other hand, MPA values may be as misleading as "Handbook" data in the hands of the uninformed. Suppose that after adequate dilution the isotopes in question are again concentrated by plankton. Since fish feed upon plankton, a serious set of circumstances might arise when the fish are in turn consumed by people. The environmental phase of radioactive control, therefore, dictates that engineers not only think of physical, chemical, bacterial or biological terms but broaden their scope to include radioactivity.

Conclusions

The rapid use of radioactive isotopes by industry in general, hospitals and research organizations, is an awakening example of the need for the civil engineer to keep pace with modern developments and to accept his part of the responsibility. Every phase of engineering and science will be in contact with problems posed by the wide-spread uses of radioactivity, even though only a few engineers will work directly for the nuclear power industry.

The civil engineer has a new set of tools in radioisotopes, and new problems created by these same radioisotopes. If he is to meet the challenge he must prepare himself accordingly with the fundamentals of modern physics, statistics and possibly electronics.

Rating Teaching Personnel for Advancement Purposes

By EUGENE H. BROCK

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Introduction

The business of rating professional personnel regardless of field has been proven, wherever tried, to be a most delicate procedure. The person or persons responsible for such a task must exercise a special kind of imagination which enables him or them to visualize the extent and character of work done by an individual during a work year. There is a certain amount of dealing with the unknown—of looking into the crystal ball. The "individualism" characteristic of the teaching profession particularly does not lend itself to close grading. The efficiency of college personnel is not so evident as that of personnel in industry, hence, performance of the individual is not based primarily on the efficiency with which he or she works. The validity and worth of the individual's work is not always discernible in the end product (graduate). Results cannot be tabulated day by day or even year by year. It appears, however, that the following points might be considered as evidence of good teaching qualifications and consequently may have considerable bearing on promotions, etc.

1. Mental ability and alertness of a high order
2. A high sense of social responsibility —rendering graduitous public service
3. Interest in the profession with a motive for service
4. A foundation of knowledge upon which a career can be built by experience (with a desire to learn and expand constantly)
5. Activity marked by individual responsibility
6. Self-expression implying a joy in one's work
7. Sharing advances in professional development

The successful management of labor and the study of human traits relative to employment environment is of prime importance and it appears logical from the many difficulties involved in evaluating evidence for fair ratings and promotions that perhaps the best approach would be from the use of an independent personnel department working in conjunction with the various administrative persons concerned. Many large organizations have found this approach to be both economical and practical.

Present salary advancements seem to be given unexpectedly—even to the receiver and though supposedly done in strictest confidence, the information is soon spread throughout the department concerned. This is a continuous source of irritation to other members of the department who perhaps feel that their performance deserves the same consideration. One "sore-head" can spread a tremendous amount of discontent in the college system. The point being attempted is that salary increments do not now follow any regular pattern in most institutions. Other criticism is more or less directed toward the college-wise system of salary adjustments. As an ex-

ample, School A is able to pay its members more than School B, and Department P in School A is paying its members more than Department Q. In many instances, certain departments seem to be able to secure pay and rank raises more readily than other departments. All of this leads to an indisputable source of trouble and discontent throughout the institution following such a pattern regardless of how well the administration keeps the facts from the staff. Personnel will discuss these matters when and wherever two or more get together.

The fact that colleges as a rule pay less than industry is well known and the individual entering the college profession is certainly aware of the differential. It does not appear that this circumstance has very much to do with the criticism of the average college advancement system. Colleges, as a rule, offer many advantages that industry cannot hope to offer and through proper channels these facts and advantages could be made felt throughout the staff. The whole pay and rank situation seems to stem from the lack of a progressive evaluation of what each individual staff member does and is capable of doing for the college and from the fact that too many persons are treated differently from other persons without good and apparent reasons. Salary increments are not to be likened to prizes at a drawing or party, but must be yearly and in all instances follow a set pattern unless good reasons have been advanced and are known by all concerned.

Objects of an Advancement Program, Rank and Monetary

Every individual employee in any organization is interested in the advancement program sponsored by that organization. Many prospective employees accept or refuse employment on the basis of such an advancement program and in many instances terminate their employment because of the lack of a solid program. The administration should be able to point with pride to the possibilities afforded an incoming employee and present employees under the institution's advancement schedule.

The advancement program should be divided into two phases; yearly salary increments and, secondly, advances in rank when the person has met the requisites for a particular rank. These requisites are based upon performance in the previous rank, experience and education. It is assumed that tenure will play an important position in the establishment of the various ranks, but it must be emphasized that tenure in itself does not qualify a person for a raise in rank.

Questions Relative to Rating Personnel and Establishing an Advancement Program

Questions and problems related to the establishment of an advancement program are listed below:

1. Does the party or parties responsible for advancement use a specific method for determining advancement on the various levels?
2. Is there a scale used whereby the individual might expect a percentage salary increment (depending upon monies allotted the institution from budgets) each fiscal year so long as their performance is satisfactory?
3. What does the administration consider as major factors in the advancement program? (These may be included in the next question.)
4. What weight or credit, if any, does each of the following items receive in the advancement program?
   a. Degrees
   b. Teaching experience
   c. Industrial experience (where applicable)
   d. Tenure in one's present job
   e. Professional registration or recognition
   f. Contribution of professional papers and books
   g. Research
   h. Recommendations by responsible and qualified persons.

There is no implication intended that it is possible to extend an exact value to any of the above listed items, but it is a proven fact that under normal circumstances a method of weighing groups of such characteristics is possible and feasible. It is highly essential that the staff know that administration at least considers such qualities as requisites for regular promotion and that all or which parts are considered in the annual review of personnel.

Reasons for Items Suggested in Advancement Program

a, b, c. *Degrees, teaching experience and industrial experience.* It is a well known fact that a statement of degrees earned, plus years of teaching experience plus years of industrial experience is not an infallible nor an accurate measure of the quality of teaching one does or is capable of doing. There will always be individual exceptions to these measures of teaching ability. There are excellent teachers who do not hold degrees of any sort and likewise, there are those teachers who hold Ph.D.'s from our best institutions who do not possess the qualities required for good teaching. Yet it must be recognized that by and large training as evidenced by advanced degrees and experience in both industry and the teaching profession are requisites for a well-rounded teaching experience. Credit must be given for having such requisites.

d. *Tenure* does not necessarily qualify one for an advanced rank nor does it justify an increment in salary, but every organization must promote tenure if a sound basic organization is maintained. There should be an approximate time limit that a person would normally remain in a given rank. This will certainly not hold true in all instances, but primarily refers to those persons who have done a good job consistently year after year. It seems sensible to promote an individual out of the instructor class at the end of five years. If he is not worthy of such a promotion at the end of that period, he should be released from his duties; continued service might be harmful to his students or the college. An associate professorship might be granted at the end of ten years of good service and the full professorship should be given between the fifteenth and seventeenth years. It is understood that there will be exceptions to any specific objective, but such an objective would bring about better relationships among faculty members.

e. *Professional registration or recognition* must be encouraged with more than just a "pat on the back." Many institutions have set up professional registration as a requisite for new employees, particularly in the engineering college. It seems feasible to require some professional recognition as a requisite for all personnel entering the teaching profession, and if possible, pressure should be applied to existing personnel to improve their status.

f. *Contribution of professional papers* perhaps should be included in the previous paragraph. Certainly some credit should be given to those who are willing to devote time and effort to the writing of books and other publications. Such work strengthens the originator and indirectly promotes the welfare of the college.

g. *Research* is an intangible factor and must be weighed very carefully in the over-all advancement program. Many persons do not possess the qualifications for pursuing research yet these persons may be excellent teachers. However, many teachers do an excellent job in research and certainly should be encouraged to pursue this qualification. Most teachers would benefit immeasurably from part-time work in research. This would be particularly true where the person is unable to afford time in industry. The teaching experience would be enhanced by actual experience and know-how in a direct application of knowledge in their particular or related fields. Too, the students would benefit from the freshening

effect of other interests than the general course requirements. Most teachers who are doing research work along with their teaching find that there is ample opportunity to bring some of the experiences in research to the classroom. Some weight should be given in the advancement review to those who possess abilities in the two professions, but not stressed to the extent that good teachers become prone to forget their teaching performance to seek the bounties of research.

h. *Recommendations by qualified persons* will be discussed in later paragraphs as a part of the scale ratings. It is sufficient to state here that all recommendations (including student ratings) should be considered, but as a guide only—not as the final measuring stick.

Specific Suggestions for Rating Personnel

It seems both possible and feasible, contrary to the belief of many well-informed people, to evaluate the performance of college personnel. Present evaluation is based on many minor and sometimes not correlated items such that the real reasons for salary increments and rank raises are often overlooked. It is also true that many institutions do not have a bona-fide advancement program and a majority of the institution's personnel flounder around attempting to hit upon a quick way or means of attracting sufficient attention to "rate" a promotion. In some instances this effort is carried on to the extent that the real objectives of teaching are forgotten. On-the-job performance is the only legitimate means of obtaining a promotion and all evaluation should be based on this philosophy. Such evaluations should fall into three natural categories:

1. Normal or average performance based on assigned duties
2. Above average performance based on assigned duties (it is assumed that such persons carry on an active program above assignment)
3. Below normal performance.

The phrase, "natural categories," was used because there will always be a natural selection of those three levels in the various departments and in some instances on an over-all college level. Those persons gifted with outstanding characteristics or who are willing to do extra work will enter into their job in such a manner as to be indispensable or at least be noted by all concerned. Below average performance will likewise be noted just as strongly.

Performance is the key to a workable advancement program. And those persons responsible for advancement must adopt a means for differentiating the various levels of performance. It is the contention of this paper that the three levels of performance listed above are sufficient to do the job.

The Weighted Scale—Performance Method of Determining Advances in Salary and Rank

It is believed that an established practice of using the weighted scale similar to that used in industry along with performance evaluation will eliminate many difficulties which have been experienced with existing systems and in so doing will promote tenure of the staff. Figure 1 illustrates a scale which lends itself to such a system as recommended in this paper.

It will be noted that three curves are used; one for each of the standard degrees. Salary is based largely upon the number of years of acceptable experience. Each of the curves used has a base salary which would be considered as the minimum salary to be paid for entrance into the institution's staff. Normal or average performance would constitute reason for following the curves. Should legislative action be of such a nature as to prevent following the curves as shown (budget wise), percentage raises, based upon monies in the budget and percentages relative to the scaled curves would be granted. This would assure all personnel the right of obtaining salary increments

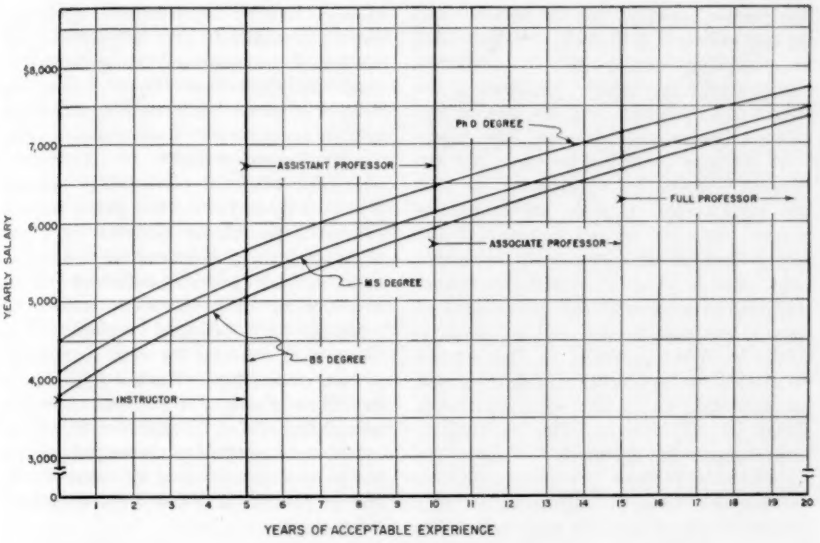

FIG. 1.

on the level with other fellow workers regardless of department.

Initial Hiring Factors to be Considered

The institution should adopt a system of hiring which would include the following concepts:

1. Personality
2. Scholastic record (to indicate promises of development in a specific field. To be used with other factors)
3. Experience
   a. Industry
   b. Teaching
   c. Other
      (The number of acceptable years would indicate partially the base starting salary)
4. Evidence of ability to cooperate with others
5. Indicated promises of future development
6. Interviewer's evaluation
   a. Departmental level
      (1) Staff
      (2) Department head
   b. Dean or personnel department
7. Unusual contributions in field of assignment
8. Character of experience (partially evaluated in item 3)
9. Recommendations by qualified persons

Length of experience must be weighed by factors representing true values of experience to the job applied for. As an example, a year of applied research in industry might be considered equal to two years of teaching experience in some positions. One year of work in construction might be equal to 1½ years of teaching experience to a position in the Civil Engineering Department and on the other hand might be practically worthless in other positions. Regardless of how difficult this job of evaluating may seem, many fine organizations have used it successfully for many years.

Specific Example of Initial Hire

Person applying for the position is a graduate of an acceptable institution. He has a Master's Degree in the field of application. Grades on his transcript were acceptable and recommendations from responsible persons above average. A telephone contact has been made with

the person applying for the position and he has indicated that he is still interested in accepting employment if conditions are mutually agreeable. The head of the department involved requests that the applicant (where possible) visit the college —at the *expense* of the college. The applicant is given an opportunity to visit the department involved and normally several members of the department are given time off to spend with the applicant. The head of the department should not discuss policies of the department or any other matters of college business until the other members of the department feel the applicant will find himself an agreeable place in the organization. After the department head has had an opportunity to thoroughly discuss the applicant with those persons responsible for the interview, he will make his own personal contact with the applicant. The head of the department will then send a record of the interview together with the recommendations of the department. The final interview of the applicant is with the dean of the school involved. If an offer is made, the applicant should be made aware of how his particular level of employment was reached. The advancement program should be explained and other details relative to the objectives of the program fully explained. Such an introduction to the college will assist the prospective employee in his integration into the college environment.

The applicant illustrated was offered $5150.00 based upon four years of acceptable usable experience (other qualifications being acceptable).

Rating an In-service Employee

The principal source of information for rating an in-service person is the department in which the person works. This statement does not imply that the head of the department should be the sole judge of performance and qualifications of each member of his department. As a matter of fact, this does not seem to always be the most practical answer to the grading problem. In many instances other departmental personnel should be asked to give additional information (a maximum of two persons other than the department head). Such information must be treated confidentially and in no cases dwell on personal items. Circumstances relative to information should be obtained (friendship, competitive feeling in same field, grudges, etc.). Should a person be classified in a substandard rating, the head of the department should provide sufficient written evidence to back the classification and provide the personnel department or Dean with reasons for retaining such a person on the staff. Such a rating would constitute reasons for administrative personnel to have an extensive review of circumstances relative to the employment of the person—considering all elements relative to environment and departmental relationships.

Average performance ratings should follow a set pattern through the scale. From Fig. 1 it would be possible to determine salaries of employees A and B with four and sixteen years of accepted experience. Employee A (B.S. Degree) would expect to get a raise of $22.50 per month, while employee B (B.S. Degree) would expect to get a $15.00 per month raise. The curves illustrated tend to level as the number of years of acceptable experience increases.

Above average performance ratings would be subject to a review by the Dean of the School involved and perhaps by the Dean of the College. An additional salary increment above the scale might be granted and in exceptional cases, a raise in rank might be justifiable. It is difficult to substantiate a definition of what constitutes a rank raise, but certainly in any case every rank should have considerable meaning for the participant. Tenure should mean a gradual raise in salary and over a period of time a raise in rank if performance is satisfactory.

Conclusions

In order to build a faculty strong in all phases of activity and high in morale,

it will be necessary to adopt an aggressive and progressive advancement program for all staff members. This statement does not intend to imply that each employee will receive an increment in salary each year nor does it imply that each employee would expect a raise in rank each specified period, but does mean that each employee will be able to justify his position on the advancement curve and can expect proper treatment and explanations for below-average performance and for above-average performance.

It is believed that the initial hiring of an employee should be done with the knowledge that the applicant has the necessary qualifications to follow the advancement program. Necessary steps should be taken to assure the continued performance of that individual. The following seems feasible:

1. A suitable orientation program during the first year of employment, departmental and college-wise.
2. In-service teaching training—colloquium programs
3. Periodic interviews by department heads and other administrative personnel. (Performance review and general consultation)
4. Recognition of advancement
   a. Degrees
   b. Professional registration
   c. Professional recognition
5. Other constructive criticism, etc. The use of the student rating system is a part of this item. This person believes that such a rating can be made to work properly and be most helpful to every employee)

An Integrated Approach to Basic Mathematics

By W. R. VAN VOORHIS

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The importance of basic mathematics in engineering curricula is recognized by the Engineers' Council for Professional Development. In fact, there is almost universal agreement among members of the engineering profession that basic mathematics, along with the physical sciences, forms the foundation of engineering training. In discussing factors of major significance in curriculum design, the Committee on Adequacy and Standards of Engineering Education emphasized the sustaining value of mathematics in the curriculum.[1] The report pointed out that the "greatest potential for future development in science and technology is to be found in mathematics. An engineer with a good knowledge of mathematics is in a position to read with understanding and profit in physics and chemistry. Likewise, as his interest and need may expand, he may read further in the applied sciences, such as mechanics, elastic stability, advanced thermodynamics or fluid mechanics." In continuing the discussion of new applications of science to engineering situations, the report pointed out that "mathematics not only becomes the support of the group of courses that will obsolesce least," but that it also "becomes the means of further technical growth as befits the graduate's interest and need." It is apparent, therefore, that course content, arrangement of topics, and methods of presentation are all subjects of great concern to those of us who are responsible for the training of engineers.

The Conventional Offering of Separate Courses

As is well known, the material ordinarily classified as "basic mathematics" has been taught in separate courses with little emphasis upon connecting the concepts developed in the various topics. The conventional method of approach has usually taken the form of fairly standardized courses described as college algebra, trigonometry, analytic geometry, and so on. Although the scope of material that can be included under the heading "basic mathematics" is arbitrary, there seems to be some justification for looking upon the three courses named as basic in that much of the groundwork for more advanced study is developed in these courses. In fact, most course outlines seem to emphasize that development of skills and preparation for later courses are their fundamental objectives. Let us, therefore, confine our attention to those topics ordinarily treated in college algebra, trigonometry, and analytic geometry, together with such applications as may be found in the fields of mechanics, physics, and so forth, as, for example, moments of force, uniform motion, and other simple applications. It is fairly safe to say that there are many teachers of mathematics, and certainly a great number of members of enginering faculties, who feel that the formal presentation of these subjects should be critically examined, not only with the view of obtaining greater mathematical competence of their students, but also to develop appreciation of

[1] S. C. Hollister, and others: "Report of Committee on Adequacy and Standards of Engineering Education," THE JOURNAL OF ENGINEERING EDUCATION, Vol. 42, p. 252.

the interrelationship of mathematics and other phases of their training.

Trend Toward Integration of Topics

The formal presentation of the topics of basic mathematics in separate courses is so easy that the advantages of some sort of integrated approach are often overlooked. In a paper presented before the Indiana Section of the Mathematical Association of America, Professor M. E. Shanks of Purdue University made some definite remarks with respect to this point.[2] He pointed out that the "classical algebra, trigonometry, and analytic geometry sequence has had remarkable survival value." He goes on to say that "when one considers that it has been in existence for several generations without essential change (except for some dilution in content) it is hard to imagine how such a fossilized entity could so long endure." Professor Shanks contends that "we are surely ripe for a change."

Most colleges have, for many years, followed a line of least resistance, presenting the basic courses in a manner so familiar to all. Typical examples of the formal presentation show quite clearly the lack of any blending of ideas, although in many cases it is actually very difficult to prevent the bringing together of certain topics. For example, extensive drill is given in solving quadratic equations in algebra, with the unknown usually restricted to the letter x, but consideration of the same equation if the variable happens to be a trigonometric function is deferred until the course in trigonometry. Very seldom are the symbols of calculus, or those employed in electricity and other applications included in lists of drill problems. Yet it is certainly possible that even in the limited sense using the symbolism of other courses can prove to be beneficial to the student in his later applications. As another example of the questionable advantage of a formalized treatment, consider the study of the straight line. A student receives much drill in handling linear equations in algebra, but is denied the pleasure of graphing the linear function until he has reached the study of the straight line in analytic geometry. Only in rare instances does he fit a straight line to data, and this task is usually looked upon as an extra topic that can be taken up at the end of the course, if time permits.

Although the formal method of presenting basic mathematics has had a firm grasp upon our colleges for many years, increasing efforts are being made today to blend the topics in some manner. For evidence of this trend, we need only to examine the course descriptions in the college catalogs. In making a study of the catalogs of 25 leading engineering colleges, the following results were obtained:

	1941	*1954*
Integrated	5	16
Conventional	20	9

Of these 25 colleges, 5 offered in 1941 some type of integrated program, whereas 20 of them were offering the conventional courses. The integration of topics at that time consisted chiefly of offering in one course a few topics from one or two of the other courses. For example, trigonometric equations might be taken up in the algebra course; or perhaps combinations and permutations might be given in the analytic geometry course. In 1954, 16 of these same 25 colleges are offering courses that combine, in some fashion, topics from the three conventional courses, and 9 of them are still offering the separate courses. In reading the course descriptions, one obtains the impression that a greater attempt has been made to bring together topics in some planned fashion.

The change in the course content arrangement of these colleges is evidence that there is a tendency towards the adoption of some type of integrated or unified

[2] M. E. Shanks: "Mathematics for Engineers," THE JOURNAL OF ENGINEERING EDUCATION, Vol. 41, pp. 308–309.

presentation of the topics of basic mathematics. In a few instances, topics from analytic geometry have been combined with the study of calculus, but these are those in which algebra and trigonometry are not a part of the curriculum. It is interesting to note that not one of the 5 colleges offering a type of integrated program in 1941 has returned to the conventional approach at the end of the thirteen years.

Need for Planned Integration

The trend towards some program of integrated basic mathematics is the result, no doubt, of observations of ineffectiveness of separate course offerings. For many years my colleagues and I have been concerned over the lack of simple skills possessed by students in later mathematics courses, although they had been given intensive drill in the basic courses. The inability to make analyses of problems and to apply simple procedures already learned must be accounted for in some manner. We began to look around for an explanation. We could have reasoned that the explanation was simply lack of background on the part of the entering students, and would have certainly found many in agreement. But this would not have been a realistic solution. We had the students and it was up to us to do our part in rounding out their engineering program. We were certainly safe on one basic assumption—our students were of two groups—*above-average*, and *below-average*. Could we decide upon a set of assumptions upon which a program of integrated basic mathematics could be built? From the students themselves we learned one interesting feature which could possibly account for some of the ineffectiveness of the conventional courses. Below-average students admitted that the formal courses, containing, as they do, a repetition of much of the high school work, failed to arouse their interest in mathematics because this same kind of presentation had done much to dampen their enthusiasm in high school. The above-average students admitted that formal courses encouraged them to "take it easy" upon beginning their college career. Here they found material already rather easy and familiar to them, and so they could spend their time on other subjects. If these students reactions, then, were correct, none of our students, generally speaking, were beginning their careers with much inspiration as far as mathematics was concerned.

From instructors in other departments came the pleas for greater emphasis upon applications. Many of them felt that more use could be made of mathematics in their courses if there was a greater correlation between the time the material was taken up in mathematics and the time at which related topics were being discussed in applied courses. At first we tried to incorporate the study of calculus with the topics of analytic geometry and other basic courses, but we were not entirely satisfied with the results, because of the lack of basic skills in later courses. We decided to keep calculus in the sophomore year, treating it as an application, just as we did mechanics, physics, and other courses in the curriculum. Certain topics, however, such as the limit of a sequence, convergence and divergence, the writing of general terms of series, and the comparison test for convergence could be blended in with topics of the basic courses. Eventually, our aims became clear. We wished to establish a program that would (1) increase motivation and interest, (2) emphasize applications in other courses, (3) correlate the time of presentation as far as possible with related topics in other courses, and (4) retain at the same time the desirable features of rigor and analytical thinking that could result from the thoroughness of conventional courses.

Assumptions Underlying a Program of Blending

After much preliminary investigation we finally decided upon the following

assumptions for our program in basic mathematics:

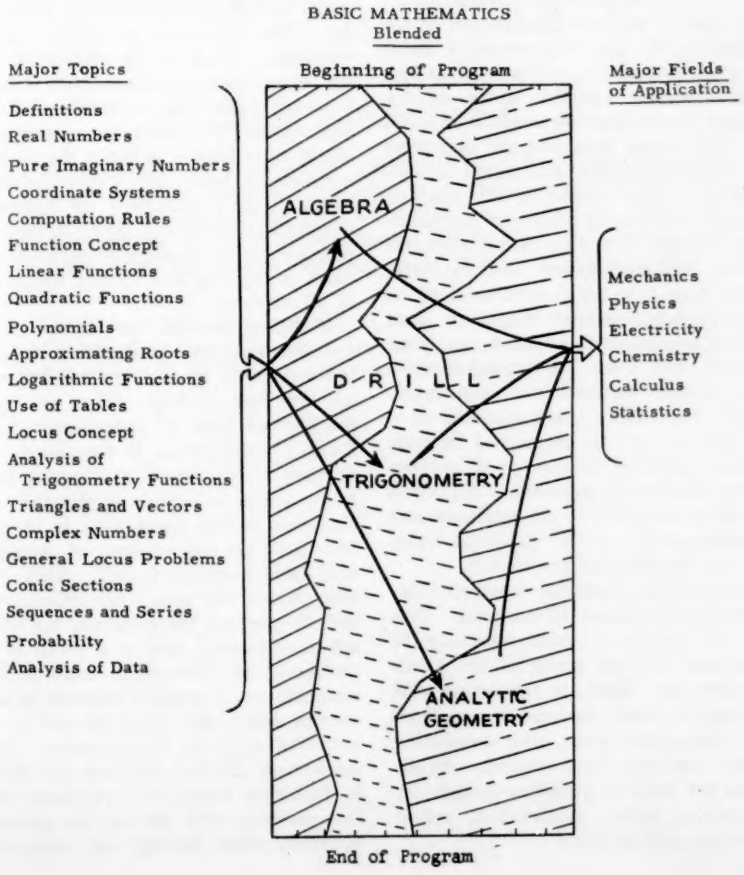
(1) Basic mathematics should begin with and emphasize the function concept.

(2) Formal drill should be interspersed throughout the program in connection with other topics which, for the student at least, are more interesting.

(3) Essential features of all conventional topics (and we found none that could be entirely left out) should be *blended* so as to give the student an appreciation of their interrelationships.

(4) The presentation should be of such a nature as to encourage the student to study the text material, gaining his own information preliminary to the solving of problems and without depending upon lectures by the instructor.

With these assumptions in mind, the course material was written and revised several times. As indicated in the accompanying chart the subjects of algebra, trigonometry, and analytic geometry appear in a vertical arrangement, instead of horizontally, and drill cuts across all topics. The width of each of the three major areas at the position of a major topic on the time scale indicates the approximate percentage of "emphasis"



devoted to a given phase in each of the time "areas."

The Process of Blending Topics

The material was designed to be ample for three quarters of work, or a total of 150 hours. As the chart indicates the emphasis is upon algebraic phases during the first quarter, trigonometric phases during the second quarter, and analytic geometry during the third quarter. In each quarter, however, topics are treated so as to cut across all three fields with illustrations and applications that can be used at the level of development. As an illustration of this blending, let us consider the treatment of the straight line.

Because of an early introduction of the definitions of the trigonometric functions, angle measure, and coordinate systems, a rather complete study of the straight line is possible in the first quarter. This topic furnishes the beginning of the locus concept, and serves as motivation for an interest in the analysis of data. Simple applications are taken from problems involving forces, electrical circuits, uniform motion, and so forth. At no time is a topic considered to be finished; but repeated usage of ideas learned are made throughout the three quarters, and ideas are expanded upon after further material has been introduced. For example, the equation of a line through two points is tied in with fitting of data by the method of average points; then "least squares" is employed after cross reference to the maximum and minimum points of the quadratic function and the study of probability.

The parabola provides another illustration of correlation of material. This conic is introduced quite naturally in connection with the study of the quadratic function. Later, in connection with more general locus problems, a more thorough treatment is given after translation and rotation have been studied. Applications are made to problems in highway engineering, bridge construction, reflector design, and so forth.

Advantages of a Blended Approach

The question naturally arises as to the advantages and effectiveness of the blended or integrated approach. In the first place, motivation and arousal of student interest in the study of mathematics are greatly increased. When beginning students are presented with a formal course in college algebra, two types of reaction are quite apparent; The above-average student recalls that the material is quite similar to that studied in high school, and consequently is inclined to "take it easy," feeling that he is already familiar with the material, and can spend his time on other subjects. He gains no inspiration to study mathematics. The below-average student is discouraged. Here he is confronted with the same type of presentation that he probably found somewhat distasteful in high school. The result, for a great many students, is failure to begin the study of engineering with the proper frame of mind. The introduction of interesting applications of an enginering flavor made possible by the blending of topics has the effect of catching and holding the interest of all students.

Probably, one of the aspects of the problem that has been instrumental in the survival of the conventional approach has been that of drill. When one begins the blended type of presentation, introduces a topic, leaves it temporarily for another one, returns to it again for a while, brings in outside applications and continues in this manner, he is likely to feel that the advantages of necessary drill have been overlooked. This, however, is not the case. By interspersing drill throughout the program, the effects are more lasting; and as a result of the continuity of instruction, more skill in manipulation is actually retained in later courses than results when the drill is concentrated early in the program. It is much more effective, for example, to drill in factoring when this operation arises in connection with solving the quadratic equation, when finding real zeros of a

polynomial, etc., rather than to give it all in one dose, and hope that the results of the injection will be permanent.

Perhaps, one of the chief advantages of the blended approach is a byproduct of the manner of presentation of material made possible by the cutting across of segments of the basic courses. The material can be written in a manner that the student can follow the unfolding of concepts, and at the same time understand the derivations and illustrations. To a larger extent he is thrown on his own, for he must do a certain amount of cross-reference reading while studying the text preliminary to solving problems. This gives practice in reading mathematical material, and enables him to experience the joy of success as a result of his own efforts, without depending upon lectures by the instructor. The instructor, in turn, has more time available for diagnosis of difficulties and special problems.

The training in analysis afforded by the blended and unified presentation of basic mathematics, the stimulation of student effort, the correlation of mathematics with other subjects, and the improved performance in mathematics in subsequent courses, are strong arguments for the adoption of this type of program by colleges of engineering.

Dues Amendment

The amendment to By-Law Four relating to dues of individual members of the Society, was passed by a majority of over 76% of the 2,283 members who cast votes. This provides for a nominal increase in dues. The dues for next year, according to the amendment, will be $8.00 for members over 36 years of age and $6.00 for members under 36 years of age as of July 1, 1954.

The Tellers Committee consisted of Dean Frederick Tresize, University of Illinois, Navy Pier; Dean R. G. Owens, Illinois Institute of Technology; and Professor E. F. Obert, Northwestern University.

Discussion of Preliminary Report of A.S.E.E. Committee on Evaluation of Engineering Education *

By ROY M. GREEN

Dean, College of Engineering and Architecture, University of Nebraska

A More Logical Suggestion for Improving Engineering Education

The report contains much material of great significance. A major weakness rests, however, in its many contradictions and vacillation from one point of view to another. This weakness, in my opinion, results from not arranging facts and opinions in the order of their importance in arriving at recommendations. What I believe is such an arrangement is given in the following pages.

1. Our duty as engineering educators is to develop *MEN*. Our educational programs should be designed to assure the *maximum rate of progress of every individual, student and graduate, as he develops in the engineering profession.* This has been our goal in the past and it would be wise to keep reiterating it in our speech, writing and thinking.

The report however departs from this philosophy on page 1, paragraph 2. *"It is the responsibility of engineering education to provide that kind of educational preparation which will assure maximum rate of progress of the engineering profession."* Again on page 25, paragraph marked 6, *"This concept places service toward advancement of the engineering profession first on the list of objectives of engineering education."*

Placing the development of persons below that of scientific findings for a profession is a dangerous backward movement in a free society. In the end it will wreck both the society and the profession.

2. Engineering College graduates play a vital role in the protection of our nation and the preservation of our standards of living. Both *quality* and *numbers* superior to our present supply are required. (Page 13, paragraph 7) "Higher selectivity would decrease the number of applicants *at the very time when national survival calls for the elimination of the present shortage of engineers."*

This is an accepted truth by practically everyone, yet on page 24 we find this: "1. In a limited number of institutions it would be possible to choose between the professional-general or the professional-scientific approach to engineering education and to *select the student body* to fit the chosen curriculum pattern."

This can not be a serious recommendation if the statement on page 13 is correct, and I believe it is. In 1946 a few engineering educators urged all college deans to quota the number of veterans, by rejection, so as to *save* the profession from a disastrous oversupply—yet today our "national survival calls for the elimination of the present shortage of engineers." As citizens of the United States, what right have we to prejudge

* Dated October 10, 1953.

all our young men by saying you go this way—to engineering—and you, over there, go another way to a place between engineering and some other activity. (Professional-general service is defined as between engineering and many other activities on page 18, last paragraph.)

3. The educational development of a constructive professional man does not end when he quits attending a college or university, regardless of 4, 6, 8 or 10 years attendance. (See page 7) "It is difficult to over-emphasize the necessity of learning how to study and of continuing study throughout a whole professional career." (Also see page 8, paragraph 3 and page 18, paragraph 3.)

This is a truth which no one will flatly deny, yet in the report, we have suggestions indicating that unless development is accomplished in college, it can never be achieved. (Page 8, paragraph 3) "The technical goal of engineering education (I assume the college program) is preparation for performance of the functions of analysis and design or of the functions of construction, production or operation with *full knowledge* of analysis and design of the structure, machine or process involved."

(Page 15, paragraph 6) Speaking of the necessity for more than four years of development, the report continues "For many, this increased training will have to come from graduate study at the highest professional level. For others, industrial experience or self-study may suffice." Does this mean if one takes graduate work he needs no self-study afterwards? Is college the end? If it is, I believe it is also the end of the engineering profession. As educators, have we lost our way in self-admiration? (Also see page 12, paragraph 5 on Humanistic-Social studies.)

4. No system of pre-judging of students is perfect. The earlier judging is attempted, the more imperfect its results. Any educator who has followed predictive-testing has observel classical examples of men who finally proved themsevles to be excellent students who were, by prediction, failures or near failures. (This is acknowledged by reference page 13, paragraph 7, given above.)

Under the recommendations, however, given in the report, the men who are to be the leaders in the profession 25 years hence will be selected at or near the beginning of their undergraduate career.

5. Practically all educators will endorse every detail of that part of the report entitled "Requirements for Admission" on page 17. Note that this firm and inclusive recommendation permits even a marginal or rejected student by predictive methods to have a fair chance to prove his eligibility for a constructive education.

Basic Facts

We therefore have five basic facts which are almost universally accepted, namely:

(1) Our primary duty as educators is to develop *men* and not to discover new scientific facts or accumulate new scientific data.

(2) Our Nation sorely needs more men with higher educational development in engineering in all its aspects.

(3) Education must continue throughout the life span of a man.

(4) Systems of pre-judging are not perfect and the earlier judging is attempted, the more errors are made.

(5) We have a reasonably acceptable guide for admission. In other words, we have reasonable agreement upon when the primary responsibilities for the education of engineers is *ours.*

With this set of facts, why is it not sensible to define the ultimate goal of a fully developed engineer, then determine what can best be done in the brief academic interlude when the student is in college? (Such an attempt was made at the University of Nebraska.)*

Since we seem to be agreed upon the

* Listed at the end of this article.

requirements for admission to an engineering college, we are also agreed that the starting point is the same for all—the highly gifted learner and the less brilliant student. We should be able to reach reasonable agreement concerning minimum coverage in the basic sciences and mathematics. All students should be required to reach these requirements but this does not prevent the unusual students (say from 5% to 25%, depending upon the class) from going much further in these basic areas.

This superior group can be fairly well identified by the time they have worked with the faculty for 2, 2½ or 3 years. Such students do not need many illustrations of the techniques of applying basic science to engineering problems and could, therefore, lay a broader and firmer foundation in the basic areas. This would avoid the inevitable losses of manpower resulting from an earlier screening and would make the relative capacity of the potential engineering scientist much greater and would not lose the effect of their inspiration on the rest of the student body.

Those who needed the repetitions of application courses would go into the professional-technological fields. This is a field the report does not envision but is an important one to contemplate. The report describes "general professional engineering service" (page 18, last paragraph) as being *between* engineering and a great variety of other things. In other words, professional-general is not engineering at all according to the description. Hence, the recommendations of the report imply splitting engineering wide open. We do not need division, we need consolidation. Engineering involves a wide expanse of human effort covering the whole spectrum from scientific to technological in all its aspects. Our selection should not be between the alternatives of scientific and general but should rather include *both* scientific and technological. Both "bifurcation" and "starring of curricula" are definitely backward movements and can only cause confusion, distrust and dis-unity in our society. We must strengthen our educational programs not tear apart the structures of engineering education in the United States.

A Suggested Statement of Policy for Engineering Education College of Engineering and Architecture University of Nebraska

Complete competence in engineering would include the following:

a. An understanding of mathematics and the physical sciences; a knowledge of the characteristics of materials; and familiarity with engineering methods;—resulting in ability to analyze, design, construct, operate or manage engineering works or projects.

b. An understanding of economics and finance;—resulting in ability to appraise the economic aspects of engineering works.

c. An understanding of the fundamentals of human conduct and the principles of management;—resulting in ability to organize the efforts of individuals and groups in an effective prosecution of engineering works.

d. A facility in forms of expression;—resulting in ability to discourse in written and oral form in the language of the arts as well as in the symbolic language of science.

e. An understanding of the evolution of the social organizations in which we live;—resulting in ability to appraise the influence of science and engineering on their development.

f. Familiarity with the great documents of arts, morals and religion;—resulting in an appreciation of the dignity and worth of human personality, the principle of social justice, and the principle of sharing for professional and social gain.

g. An appreciation of the obligations of citizenship;—resulting in a readiness to give intelligent service in the improvement of home, church, school and state.

h. An enthusiasm for learning;—resulting in a burning desire to continue the

study of engineering and to search for the values in other fields of thought.

Such competence is the goal of a lifetime and not that of the academic interlude. The academic education in the purely technical field of engineering does not, and never did presume to equip the student with the requisite knowledge, or technique of practice which, per se, allow him to function as a professional engineer. The character of the technical courses in engineering curricula should be such that the student's time is utilized in attaining two major objectives. First, that he gain the fundamentals upon which engineering is built, and second that he catch the spirit of engineering to the degree that he will continue the studies which lead to ultimate professional competence.

In the academic span of the total education of the engineer only a beginning is made in the field of engineering practice. Likewise, only a beginning should be attempted in the broad field of the humanities, relying in both cases upon the developed interest to carry the student toward his ultimate objective of professional competence.

Regardless of the number of credit hours required to earn the degree, each course to be taken by the student should be justified by the following reasons:

1. It serves as a positive aid in the ultimate achievement of at least one of the objectives (a to h).

2. It is definitely a part of the total education which cannot be achieved as well after graduation without a great sacrifice of time.

Axioms of Curriculum Change

By HERBERT A. SAWYER, JR.

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Consideration of engineering curriculum changes prevents stagnation, adds to our perspective, and, most important, may lead to real improvements in present curricula. However, too often such consideration is confusing and sterile of production of real improvements—all because of neglect of one or more of the following "axioms of curriculum change," compiled from the writings, correspondence, and conversations of many colleagues, who deserve more credit than the space available allows.

1. *Additions must be matched by deletions.* Cries for more communications, humanities, basic sciences, business, or creative design are meaningless unless the equal quantities of course material which must be dropped to provide room are specified. Present four-year curricula are now crowded to the limit, and the division of opinion on the five-year curriculum eliminates it as an immediate possibility. The question is not what is desirable, but which is *most* desirable.

2. *Increasing the exercise of student initiative is equivalent to adding course material.* If course progress is by the trial-and-error of student initiative, the rate of imparting scientific discipline is reduced 50 to 80%, thus increasing time requirements two to five times. The teaching load may be increased even more —increased individual attention is required to coordinate the wide variation in student progress and to correct false concepts and bad habits arising in individual students. Furthermore, only the cream of the class will exercise initiative, the rest following. Yet stifling of initiative would be disastrous. The solution of this problem, the most vexing in all of teaching, involves a nice balance between the advantages of student initiative and the economics of curriculum time and teaching resources, remembering that much initiative development can be deferred to the impelling practical situations of postgraduate years.

3. *Improvement of teaching efficiency is an insignificant factor.* We must strive for such improvement (to even hold our own), but it cannot serve as a basis for expansion of curriculum material. Teaching efficiency may have improved 10% in the 2400 years since Socrates, but this does not mean it will improve 10% in the next five years. Engineering teachers will still be humanly imperfect, and there are not many short cuts, discovered or undiscovered, in teaching students how to think.

4. *Overlapping of course content has some advantages.* Repetition is the key to thorough learning. Also, some overlap is necessary to show course interrelationships. Overlap at inconsequential points is obviously wasteful.

5. *Creation is an art, not a science.* Creativity and basic science cannot be increased simultaneously in the technical part of a curriculum. Creation must be discouraged when the child learns his multiplication tables, when the medical student is learning anatomy, when the law student is learning Roman law, and when the engineering student is learning to draw free bodies. Anyone, including the child playing with blocks, can be creative, but creativeness, to be worth any-

thing, must be based on discipline. The effective engineer has learned to limit his creativeness to the narrow paths useful to men and based on scientific and socio-economic principles. Only after these principles are learned can the engineer begin to learn and practice the art of engineering creation—the art which distinguishes him from the scientist.

6. *The four undergraduate years merely initiate professional training.* For *all* students, at least four postgraduate years of industrial "internship" are an integral part of professional training, and any curriculum study must consider these years. Because the body of basic principles and theory which the engineer must master is growing, more and more of the art of creative engineering must be learned after graduation and in this internship. Incidentally, changes in undergraduate curricula must involve careful weighing of industrial demands, even at the time of a "sellers' market" for engineering graduates.

For *exceptional* students, graduate work is also an integral part of professional training, and curriculum studies for such students must consider these years. Graduate work, presently so variable in quality and quantity, is by far the most fertile field for evaluation and change. Here the gifted student is shortchanged, if anywhere. Probably the exchange of ideas which graduate accreditation would stimulate would alone justify it. Of course, more diversity should be allowed in accreditation of graduate curricula than in undergraduate curricula.

7. *"Bifurcation" is on the horizon.* If the ratio of engineers to total population continues to increase, the broadened base of engineering education will eventually force our acceptance of undergraduate segregation of gifted students preparing for graduate work, just as the adoption of universal high school education has led to our acceptance of segregation of college-prep students in high schools.

8. *Extraneous activities are not good measures of curriculum teaching quality.* A teacher who is distinguished in research or graduate instruction, two valid functions of a university, is, however, not necessarily distinguished in performing its third function, undergraduate instruction. Nor is the extent of consulting work or professional-society activity a good measure of excellence of undergraduate instruction. Nor is evaluation by immature students. A reliable measure of instructional quality is much needed.

In summary, curricular revision never involves a simple choice of black or white. When all factors are recognized the choice is usually between closely matched alternatives with the time factor often governing.

Motivation in Engineering Education

By EDWARD M. BENNETT

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Consideration of the basic patterns of motives that urge young men into engineering can often serve as the first and best basis for increasing the over-all efficiency of the engineering educative process. When the conditions of education are such as to thwart, inhibit, and otherwise threaten or frustrate the needs of the student, the educative process becomes inefficient to the point of obsolescence or uselessness. When, however, the needs of men are recognized and taken into account, in planning an educative effort which eventually leads to gratification, students can be expected to exert all necessary efforts. For a student, as for anyone else, where a goal is not attractive, effort toward the goal is folly.

There are a set of pressures—cultural, social, and individual—that direct individuals toward an engineering career. Although each individual will evolve as a unique pattern of these pressures, consistencies, general tendencies, and trends can be noted. The needs of persons who seek an engineering education are but slightly different from those who strive for competence, acceptance, and general gratification through other fields of endeavor.

The cultural core of the concept of engineering hinges upon a basic belief: an individual human being can master the rules and processes of nature, and then turn them to his own purposes. Accepting such a cultural value, the individual's life is one of achievement, and not ascription. What success one gains is gained by skillful effort, individual personal exertion, and directed activity. In other words, science and technology stand upon the basic premise that one's rewards, successes, pleasures, and gratifications come from one's own fundamental mastery over the plans of natural order. Engineering is not for passive people, and so it is that one would expect the need for personal achievement, competence, and self-esteem to be high among engineering students.

The Engineering Student

The teen-ages are unquestionably a period of reorganization for the average present-day adolescent. Childhood modes are no longer adequate. Dependency and conformity to parental standards no longer elicit much reward and respect. The adolescent boy must show his own skill, make a name for himself among his peers, and strive for a feeling of self-respect based on how he is respected by other adolescents. The prize skills of adolescence at the present time, the skills most worth having in the eyes of other teen-agers, male and female, are (1) physical prowess and athletic talent, and (2) mechanical know-how and scientific-engineering "tinkering" ability. To be male, to be popular, to be wanted, one must show off one's "self" by acts of symbolic mastery; mastery over people in physical activity and mastery over things by technical advantage. The hot-rod is more than an automobile; it is a daring stallion for demonstrating combat and courage on the road. It is a powerful representative of "me," the masterful, the cam-conscious, cylinder-oriented, carburator king. It is through many pathways that the adolescent can come into his own, can find his place; but engineer-

ing is one of the best, one of the most attractive, for it is in many ways domination over the world of things. Unfortunately many highly motivated adolescents find with bitter disappointment that engineers live with numbers more than with the things they represent. Nevertheless, the things of engineering can serve as a powerful motivating force for the "self-seeking" adolescent youth.

Under the impact of any of a number of environmental conditions, a youth seeking to adjust to the other individuals in his social world—his parents, friends, brothers and sisters—may be thwarted and repulsed, rejected and denied. Finding difficult or impossible the mastery of, or the cooperation of, human associates, the youth may turn toward more controllable, simpler items, e.g., mechanical, non-social things. Gratifications obtained from success in a world of manipulatable objects may compensate for lack of gratification in primary social situations. In this way, therefore, the boy may develop an overwhelming interest and attachment for the tangible tools, techniques, and world of scientific engineering. So it might be that the motivation toward engineering serves as an outlet, displaced and distorted, of the motivation toward the social world. For this youth, his education in engineering is an education in compensation.

If, however, in the process of studying engineering, and mastering its content, the individual finds increased self-esteem, increased feelings of competence and self-worth, these may improve his social relations. Two alternatives often then arise. Recognizing engineering as the source of his social success, he increases his interest in engineering. It becomes, in effect, the stepping stone toward gregariousness. He is now one of the gang; the engineering gang.

However, it often happens that the increased social gregariousness reduces the need to compensate through engineering. Under these conditions, the youth may leave the profession—directly and suddenly—by transfer to a more man-oriented profession (medicine, law, etc.) or he may gradually evolve into the areas of business management, sales engineering, advertising, etc.

In general then, the motive which we might call the "interested in things" motive may be a direct interest reinforced by the cultural prestige of being a master of things, or it may be a compensatory readjustment toward things as an outgrowth of fear and failure in respect to people. More than likely it is a combination of both factors, as well as others, in each case.

In addition to the general pleasure obtained by having skills out of the ordinary, there is a specific pleasure of singular importance. A youth often feels an overwhelming need to have skills which are superior to those of his own father. With the general pace of technology, engineering and mechanical skills can serve to satisfy this desire most adequately. Through these forms of competence, it is as if the adolescent thinks, "Look at me; I can do things you cannot. Mother and the other important members of the family that I was dependent upon were always dependent upon you (the father) but now I can perform in manners that you cannot." The youth has gained symbolic superiority over the traditional childhood authority—the father. In other areas as well as professional engineering, it is quite common to find individuals gaining deep gratification from being more successful than their parents. This is not to say that the parent resents this. More than likely the father gains real vicarious pleasure from the successes of his sons. Nevertheless for the boy, this specific prestige over the parent may be a core motive.

Prestige in general is particularly important as a motive for entering professional life. One of the major reasons many engineers refuse to join unions appears to be the feeling that such organizations, associated as they are with "worker classes," are, in effect, reducing the pres-

tige of professional life. Often financial reward will be sacrificed, more or less willingly, to obtain such personal prestige. Where prestige is a recognition of worth, position, and importance by others, it is closely related to feelings of self-esteem and feelings of self-worth.

Largely as a result of the strong cultural emphasis on man's mastery of the environment, those symbols of such mastery—the engineers—are held in high esteem; they are prestigeful. It does not take long for a child to learn of this profession, which like medicine, is highly respected by many facets of the community. If a combination of circumstances lead the child, now an adolescent, to require prestige, engineering may often be chosen as a profession. Allied as it is with such important social labels as "scientist," "expert," "specialist," the label "engineer" may be a coveted thing, sought in its own right.

Perhaps the least clearly understood, most uniquely individual, and most complex factors sending students to engineering school are the accidental individual experiences—those experiences which seem so much a part of chance, so little a part of general socio-personal forces; e.g., the child who finds an old motor or clock in the basement and enjoys the curious pleasure of taking it apart, the boy who is called upon to aid in the high school science demonstration, the especially pleasant science teacher, the father who always wanted to be a physicist. These, and many other small and specific factors added to others more general, send a boy to engineering school for an education.

Over and above the many factors related to the stages of adolescence, and the specific individual, engineering has certain real cultural significances all its own. An adolescent might strive for gratification of basic urges through any one of dozens of pursuits. But, for the youth who chooses engineering or science, certain unique forces have more than likely made their mark.

In American culture at the present time the words scientist and engineer represent a class of persons with almost mystical qualities. They appear to design and control things beyond the wildest dreams of mortal men. The very qualities of natural phenomena that permit one to observe a television set miles from the source of entertainment are beyond the average man's comprehension. To most people, then, the engineer, who casually designs television receivers, automobiles, aeroplanes, etc. has talent, power, and merit beyond that open to most. There is a special language and the use of numbers in complicated ways. There is the ability to predict the behavior of machines, gigantic in size, power, or complexity. From the outside, engineers and scientists are powerful, often dangerous, secret people who help run the world. For many an adolescent, membership in this club is the next best thing to a trip to Mars. It is the culmination of a series of years dedicated to Tom Swift adventures, science fiction serials on T.V., automobiles, and ham radio.

Finally, and by no means least important, is the financial position of engineers in the community. They are oriented toward the commercial applicability of scientific endeavor, and are recognized by industry for their services. There are many fields into which a youth might turn to satisfy needs for prestige, status, power, mastery, etc., but very few in which all of these *plus* the desire for monetary gratification can be so nicely meshed.

Independent of the specific motives in question, each individual is oriented primarily toward his own need satisfaction. Further, he is particularly concerned with the extent of satisfaction he can expect and look forward to in the future. If the future appears full of pleasures and gratifications, the individual feels secure. If, however, there is an anticipation of danger, pain, or frustration in the forthcoming minutes, days, months, or years, the individual feels insecure. One

of the core motives for any individual can be simply called the need for security; the need to be in a position to anticipate that the multitude of lesser needs will be gratified. There are very few occupational areas in which an adolescent seeking feelings of security, feelings of a safe and satisfying future, can find them as well as in engineering. The cultural emphases upon specialized knowledges of physical processes, combined with the intellectual capacity required to master engineering, result in an ideal combination of many available jobs with a limited number of applicants. Engineering education can thus, and does, serve as a core device for the eventual gratification of a need for economic and social security.

A Recent Study

Two facets of the general problem of engineering students' motivation have been examined in a recent study (*1*). Three hundred and fifty engineering students were polled at Purdue University. From these, the results from three hundred and thirteen returns were analyzed. The students had been asked to rank in order of their importance to themselves, ten statements describing ten reasons for studying engineering. On the basis of these rankings, average importance scores were obtained for each motive statement. In order, the most important reason, on the average, for studying engineering was (1) general interest. The second most important was (2) security. This closely relates to Centers (*2*) findings which indicate that security is the prime job objective of the working class, and the second most important objective of the middle class. Following security, the Purdue students listed (3) personal aptitude, and then (4) scientific curiosity. Aptitude often leads to both curiosity and interest, since in the areas of high aptitude, one often gains the greatest feeling of self-esteem and competence, and through them, satisfaction. The need for (5) prestige was next. Following the first five was (6) monetary gain. This corroborates work done by McGregor and his associates (*3*) in the field of industrial psychology. There appears to be fairly consistent evidence to indicate that the personal satisfactions, self-esteem, and feelings of security in a job situation are more important than simple monetary income. The constant labor-management hostilities in the monetary area may reflect an absence of the higher order gratifications. Security, prestige, and self-esteem are hard to fight for; money is a tangible arguing basis.

Lower on the scale appeared (7) glamour, (8) altruism, and (9) gregariousness.

The final expressed motivation was (10) parental influence. Although perhaps the single most influential force on the child is the parent, this influence is apt to prove both subtle and in many cases distasteful. To be consciously aware of the fact that one, as an adolescent, is responding to parental pressure, is highly disquieting, and certainly deflating. Using the superficial verbal statements of the subjects, without intense clinical interviewing, it is reasonable to expect the parental pressures, no matter how truly important, to rank low.

When different groups of engineering students were compared, it was found that the scientific curiosity motive was of varying importance in the different engineering specialties. The electrical engineering students considered it more important than did any other group of specialists. The civil engineering students found it least important of all the specialist groups. Monetary gain was ranked highest by chemical-metallurgical engineers and lowest by agricultural engineers. Considering the gregariousness motive, the chemical-metallurgical engineers ranked it highest, and the civil engineers ranked it lowest.

The entire engineering teaching staff was polled and asked to rank the same ten motive statements in order of importance for students in general. The

final rank-order from the staff was correlated .90 (Spearman Rho coefficient), with the ordering from the students, indicating a high degree of staff insight into student motivation. The order given by the staff was (1) interest, (2) aptitude, (3) curiosity, (4) security, (5) monetary gain, (6) prestige, (7) glamour, (8) parental influence, (9) gregariousness, and (10) altruism. The only appreciable differences in ranking between the students themselves and the staff impressions of them, was that the staff played down the security and altruism motives, while raising the parental influence motive. These, however, were only shifts of two places.

Summary

Engineering students seem to have a pattern of motives with interest, security, aptitude, curiosity, and prestige high on the list. This pattern appears on the average to be known to engineering staff members, as indicated by a Purdue University study. The pattern itself appears to be a rather straightforward outgrowth of the general social conditions of adolescence in the working and middle classes of our culture, and seems to reflect the pattern which is generally found in studying industrial motivation.

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ANNUAL MEETING

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Servomechanisms in the Undergraduate Curriculum*

By CHARLES H. DAWSON

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The standard undergraduate curriculum in mechanical, electrical, or chemical engineering includes courses in mechanics, hydraulics, thermodynamics, and electricity. Regardless of the quality of such courses and of their instructors, the course content is likely to be treated as a closed entity and the interrelations of the fields of study are rarely mentioned. The student may be well equipped to solve complicated problems in a particular area but he is not able to solve simpler problems involving several fields. Too frequently, time does not permit the instructor of such courses even to mention, much less to teach, the dynamics of his subject. The student in mechanics learns $F = ma$ and $a = d^2x/dt^2$ but he never thinks in terms of $F = md^2x/dt^2$. Steady-state behavior is emphasized; transient behavior is barely introduced.

Because he is not required to exercise his knowledge of differential equations immediately following his mathematics courses, the student soon comes to believe that engineering does not require much proficiency in mathematics and resents being asked to do more than to multiply and to divide. The resulting loss of mathematical facility is doubly tragic in that creative engineering work and keeping up with one's field through reading the technical journals require extensive and increasing use of mathematics. If we admit that we are not training engineers but are giving our students a background from which they can build an engineering career, then, certainly, mathematical analysis must be an integral part of that background.

The need for improved integration of the various fundamental courses can best be met by emphasis on the dynamics of systems in an essentially mathematical course. Such a course could have a variety of names: Response of Physical Systems, Instrumentation, Feedback Control, Servomechanisms. A title including the word, servomechanisms, seems to have the most student appeal and can therefore offer the most motivation. This interest in servomechanisms undoubtedly stems from the wide publicity that feedback control systems are currently enjoying in the non-technical press as well as that due to the controversial books by Wiener. We should note, however, that the proposed standard nomenclature differs from popular usage in limiting the term, servomechanism, to those feedback control systems in which the controlled variable is mechanical position.

H. L. Hazen of MIT wrote in the *ASEE Journal* for October 1947 an apt description of the educational advantages of the feedback control field. "We find in practice that it becomes an extraordinarily effective medium for deepening and broadening the grasp of fundamental principles. Thus one immediately comes face to face with the dynamics of lumped-parameter systems including active elements. Questions of dynamic stability and of detailed behavior under transient as well as steady-state conditions must

* Presented at the Annual Meeting of the Upper New York State Section of ASEE on October 23, 1953.

be answered quantitatively. One finds that the steady-state response to periodic driving forces over a broad frequency range is equally important.

"This type of analysis, of course, requires the accurate description of the behavior of the significant elements in terms of differential equations, one of the most difficult and simultaneously most important components of the engineer's discipline. In a servo system one encounters separately or in combination such apparently diverse devices as: electric circuits including electronic devices; hydraulic amplifiers, pumps, motors, and transmission systems; pneumatic systems; and electro-mechanical devices, including motors, generators, torque motors, selsyns, multi-winding amplifier generators; to say nothing of the chemical, thermal, aerodynamic, mechanical, or other systems which are integral components of closed-cycle systems for the control of such quantities. The servo man must be able to deal quantitatively and analytically with the dynamics of such varied components and of complete systems involving them. Thus the servo field is one that compels integration of mechanics, hydraulics, and electric circuits in a way that is a joy to the educator."

Historically, due to the similarity of feedback control systems and feedback amplifiers, most courses in Servomechanisms have been offered in electrical engineering departments. For such a course as I am suggesting in the undergraduate program, I feel that the student will gain by taking the course from an instructor not of his own department; in this way both the instructor and the student are forced into more use of analogy and the viewpoints of both receive the maximum growth. Having students with diverse backgrounds in a single section is similarly advantageous.

Essential Prerequisites

The essential prerequisites include mathematics through differential equations, analytical mechanics, fluid mechanics, and an introductory course in electrical engineering. Unfortunately, few, if any, students have completed all of these before their senior year. I say "unfortunately" because I believe that the value of every course taken after a broader viewpoint is obtained is greatly increased. If it were possible to make the freshman fully aware of the common mathematical stem which runs through most of his later work, our task as teachers would be both easier and more rewarding and the mental barrier of the student toward work outside his chosen field would be materially weakened.

Although I realize the present crowded condition of most curricula, I still have the courage to ask that no less than four and preferably six semester hours should be devoted to feedback control systems as a strongly recommended, if not required, subject in the senior year. In such a course twenty percent of the time might be allotted to the setting up of differential equations and system analysis by block diagram; twenty percent to simple proportional, derivative, and integral control systems solved by classical methods; fifty percent to the interrelation of the time and frequency domain including transform mathematics, the impedance concept, the Nyquist and Bode treatments of the stability problem, and the root locus method; and the remaining ten percent to some elementary cases of nonlinear systems. Although most units of real equipment are linear only over narrow ranges if at all, the undergraduate course should concentrate on the linear system because it can be handled in a more general sense and because even its concepts are new to most seniors. The inclusion of one or two non-linear systems, however, will serve to remind the student that he still has much to learn!

Although the use of demonstration systems is certainly valuable, no student laboratory work is essential in an undergraduate feedback control course. If more time than the minimum four semester hours is available, inclusion of lab-

oratory work is both feasible and desirable.

At the University of Rochester, a six-hour elective course is open both to seniors and to graduate students. Approximately ten percent of the senior mechanical engineers take this course and their reaction to the material has been most gratifying. The present enrollment includes seniors in mechanical engineering, physics, optics, and mathematics, and graduate students in chemical engineering and optics. The same course is given in the extension school and has been well received by engineers from local industries many of whom are engaged in part time graduate programs.

In March of 1953, an "Instrumentation Conference" was held at Michigan State College under the sponsorship of this and other organizations. It seemed to me that the principal theme of the meeting was the need for all engineers to have some familiarity with the dynamics of systems and devices. Many of the industry speakers, unaware of the academic realities, indicated that every graduating engineer should be a specialist in instrumentation. This cannot be. But we can, and I hope we will, subject increasing numbers of our undergraduates to the great integrating influence of the automatic feedback control field.

In the News

ECPD Survey on Awarding Professional Degrees

The Recognition Committee of the Engineers Council for Professional Development, under the chairmanship of H. R. Barclay, has completed a survey of the awarding of the professional degree by various engineering institutions. The survey, with its excellent response—of the 146 institutions sent questionnaires, 142 responded—will serve as a basis for formulating recommendations concerning the practice of awarding the professional degree as a means of professional recognition.

Of the engineering schools surveyed, 86 award the professional degree while 62 do not. Of the 86 awarding the degree, 74 use professional experience as a basis for awarding the degree, 8 require resident graduate study and 4 include both professional experience and resident graduate study as prerequisites for awarding the professional degree.

In regard to their future plans concerning the professional degree, 69 colleges will continue awarding the degree, 2 will institute the professional degree, 13 will abandon it, 49 will continue not to award it, and 17 are uncertain as far as future plans are concerned. The survey shows that approximately one-fifth of the schools offering the professional degree have either dropped it or are making plans to do so.

The Committee also reported an increase of approximately 80% in the awarding of professional degrees in the last five years as compared with the previous five-year period. In the last 10 years, 1387 to 1398 professional degrees have been awarded, and of these, 917 to 922 have been awarded during the last five years.

The Committee believes this survey to be the most comprehensive of its type ever undertaken and will use it in formulating recommendations on the practice which they believe should be followed in respect to awarding the professional degree as a means of professional recognition. Copies of the report can be obtained from ECPD, 29 W. 39th Street, New York, N. Y.

The University Contribution to the Success of an Engineer

By H. E. HOELSCHER

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Author's Note: The ideas presented in the following paper are not entirely original with me. They may not have been entirely original with the man who presented them to me so many times during our acquaintance. However, he did more than anyone I have ever known to convince me of their validity. I, therefore, acknowledge here my debt to Professor R. S. Tour, late Head of the Department of Chemical Engineering of the University of Cincinnati. Professor Tour was, in my opinion, an engineer of the very highest calibre and a teacher of great effectiveness. I respected him for his honesty, his ability to think clearly, concisely, and effectively, and for his fairness and integrity. This paper, then, presents certain ideas concerning that which is required of a successful engineer, ideas which Professor Tour considered completely valid and which I have come to accept in the same manner.

Success in the field of engineering implies different things to different people. To some it means a high position in a company of recognized standing. Money and authority accompany such a position and cannot be considered as separate goals for those interested in striving in this direction. To others, the word success means advanced specialized knowledge and the contributions to human understanding which accompanies the use of knowledge. An almost infinite variation in shades of meanings are to be found betwen these two extremes.

Whatever the personal interpretation put upon the word, whatever the goal a man sets for himself as he graduates from the university of his choice, there are four requirements for his achievement of that goal. These are:

Ability to think
Knowledge
Personality
Luck

Knowledge must be present when a problem is presented and a solution demanded. An ability to think is necessary to use that knowledge effectively. Without this requirement, many of our electronic computing machines should be classified as successful engineers. Personality will largely determine acceptance by and into society and is of importance in developing an ability to handle people. Finally, there are many occasions when nothing more than luck is involved. Being in the right place at the right time can sometimes mean more in terms of opportunity than all of the others.

Of most interest to those in the business of training young engineers for success in the respective fields of specialization is the fact that they can provide their candidates with only one of these four prerequisites—and that in sadly limited quantities.

The ability of a person to use his mind for objective and/or creative thinking is

very likely fully determined by the time he reaches the age at which he enters the university. His personality has been formed by his home environment—many psychiatrists feel within the first few years of his life. The teacher of engineering can do little to provide his student with a personality for success. And, certainly, the professor has no formula for luck—unfortunately.

Instilling Knowledge

Thus, we are limited to the job of instilling knowledge—or, better, and more truthfully, to the job of instilling a desire for knowledge and a recognition of its value—hoping in so doing that the student will see to its acquisition by himself.

There is, perhaps, another task—sounding not nearly so lofty when set down in words, but still of importance in terms of a job to be done. This is the task of selecting, from among the many, those few who are potentially able to contribute significantly to the progress of the professions and to give these men assistance and the opportunity to develop their latent capabilities in the hope that they will make significant strides forward during their time.

Briefly then, those engaged in the teaching of potential young engineers can do no more than take (after having found) those who would likely become successful anyway—in spite of all their professors can do—and implement their progress by providing ready tools with which to work. These tools are, by and large, ineffective in the hands of those who have not already the ability and personality to make the most of them. For the remainder they provide only a means to a desired end.

The Teaching of Report Writing: A Cooperative Program*

By ISRAEL SWEET

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AND

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The Question of Need

Engineering curriculums are planned within restrictive time limits that are basically common to all curriculum design. Such a limitation has required necessarily that a concentration on some knowledges and skills be stressed at the expense of omission or subordination of others. Thus, a key question faces educators at work on course development: "What does the student need most of all?" The answer to this helps to determine what he is offered, how much of it he is offered, and when and in what order he is offered what it is judged he needs.

If industry has been correct in its appraisal of what the engineer requires by way of skills, then one skill (plus the associated knowledge) that we can be certain engineers need is the skill of communication: he must be able to effectively manage its content, media, and methods. The engineer is very clearly involved in the post-war re-orientation of industrial management to the need for clear communication as an organizational postulate. Indeed, the engineer fails in his primary function unless he is capable of fulfilling that function through communication. He must, by nature of his position (which has become increasingly administrative and supervisory), be able to transmit to varying audiences (ranging from the extremely technical and specialized to the relatively non-technical and generalized), through selective media, his information, findings, solutions, conclusions, recommendations, and decisions. Without this ability, the talents of the engineer become unusable; his unexpressed notions might just as well not exist.

The major medium of communication for the engineer in his formal organizational role is the oral or written report. Therefore, it is obvious that the engineering student must be taught the skill of reporting prior to his entry into his professional world.

At Pratt Institute, we have concentrated on the written report problem as a matter of practical decision. We believed that there could be more profitable collateral learning of oral report principles through practice in writing than if the process were reversed. This does not mean that the speech job can be handled adequately through instruction in the writing phase. We simply hoped for leakage of ability from one area into the

* This article is a condensation and revision of the paper presented at the 61st Annual Meeting of the American Society for Enginering Education: Mechanical Enginering Conference (Machine Design and Manufacturing Processes Subdivision), June 26, 1953, at the University of Florida.

other. Our sights narrowed because we had what time we had, and no more.

We established working standards for communication effectiveness. They were not intended to be spectacularly original or revolutionary, so much as they were intended to be conventionally acceptable as accurate and valid. The engineer, we believed, should know (1) business correspondence form and content requirements: (2) technical report form and content requirements; (3) the relationship between reports and correspondence; (4) style requirements and adaptations for reader needs; (5) principles and practices of grammar, punctuation, and planning; (6) types of reports and correspondence relating to routine and non-routine industrial activities; (7) methods of critical revision; (8) methods of fact-finding, evaluation, organization, content preparation, and manuscript arrangement; (9) *and, above all, the means of creating a professionally acceptable report out of a working situation existing in an engineering context.*

Items (1) through (8) are matters of information-giving and exercise. Item (9) is a matter of situation and motivation. We had to manage to develop that knowledge realistically. It is one thing to offer information to the student, tagging on to that information persuasive devices of one kind or another which it is hoped will assure the student that, sometime in the future, late or soon, he will be in a position to use that information. It is quite another thing to reproduce (as far as circumstances permit) the conditions which demand the meaningful use by the student of the information being submitted to him. With this second possibility, we hoped to see the direct translation of classroom knowledge into some real aspects of engineering working techniques.

Our problem in planning the report writing course became a set of questions: How can report writing be taught so that the enginering student will have to grapple with the report problem in terms similar to those which he meets on the job? How can we produce the atmosphere, the supervisory apparatus, the problem-solving requirement of the industrial plant? How can we put the enginering student to work as an engineer who faces the submission of a report?

If we could get the answers to these questions, we would get the course we wanted.

Our answers worked out in this formulation. The student should be doing a job of project investigation and development on an industrial job basis. He should be faced with a realistic as against a make-believe job. He should be an "employee" working within the framework of organizational relationship and responsibility. Thus, it became clear that we would have to "hire" the student. We would pay him in course credits. And his job with us would be of a most temporary nature. However, we felt that his real earnings would be contained in the functional skill that has lately come to be described in the fashionably modern term, "know-how." (We were not attempting, in any way, to plan a course type requirement, the "thesis" problem, that has fundamentally different purposes than those we aimed at. Therefore, this paper does not describe in any way the senior thesis requirement in force in many institutions.)

Meeting the Need: The Research Institute Plan

In the spring of 1950, two separately conceived courses of instruction were integrated by imposing upon them a working organization named the *1950 Research Institute*. The date numerals have been changed from year to year. The "Research Institute" plan represents an attempt to create a professional working organization within an academic environment. Its organization is relatively simple. The program revolves about two co-requisite courses offered to senior mechanical engineering students: Mechan-

ical Laboratory (ME 432) and Reports and Correspondence (Engl 492). The Chairman of the Mechanical Engineering Department serves as the "Director." Members of the Mechanical Engineering Department who instruct in ME 432 are "Project Engineers." English Department instructors of Engl 492 constitute the "Editorial Staff." Senior mechanical engineering students are the "Junior Engineers" (or "Technicians").

The operations of the Research Institute involve the issuance of investigative or developmental projects to the Junior Engineers who work on those projects under the supervision of the Project Engineers. The Editorial Staff directs the Junior Engineers through the report requirement which is ultimately submitted in duplicate to the Editorial Staff member and the Project Engineer. The Director administers the combined operations of the Institute by coordinating policy, procedures, operations, and standards. The teaching staffs utilize periodic conferences, at two-week intervals, for discussion of problems. Lines of communication for the Junior Engineers are directed through the Project Engineers or the Editorial Staff to the Director.

The Research Institute plan centers on translating for the student a series of general requirements into specific informations and techniques: (1) the formulation of engineering plans for a specific project; (2) the purposeful development of those plans aimed at achieving specified results; (3) the estimation and evaluation of findings; (4) the use of an actual purchasing system for materials procurement; (5) the submission of progress memoranda at stipulated intervals; (6) the presentation of written and oral technical reports which meet established standards.

It is to be noted that ME 432 and Engl 492 have been conducted as distinct courses. They meet at different hours during the week in separate classrooms: ME 432 for one class and six laboratory hours; Engl 492 for three class hours. Thus, each course has received its own stresses and has followed its own sequence of material and patterns of development controlled by differing course contents. Individual departmental views receive independent treatment, although such views tend to become related through the Research Institute. Integration has not meant the administrative enslavement of one department of instruction by another, a bugbear belonging to the skeptical.

The Report Writing Phase

Engl 492 was planned with two controlling purposes: (1) to train the student in the disciplines of reports and correspondence preparation, and (2) to provide a realistic link, through course arrangement and direction, of the substance of Engl 492 to the larger organizational operation embodied in the Research Institute.

We use two textbooks, which provide separate aspects of content and sometimes overlap in coverage, as the working bases for class discussion of material concepts. The 45 hours of class time are distributed in this way: introduction (1 hour); discussion of technical style (1 hour); report writing requirements (1 hour); correspondence types (6 hours); correspondence form and layout (2 hours); correspondence style (1 hour); grammar review (2 hours); technical composition forms (4 hours); technical diction (2 hours); report style (5 hours); library resources (2 hours); fact gathering (2 hours); report planning (2 hours); report layout (2 hours); visual aids (1 hour); sample report study (5 hours); oral report techniques (1 hour); oral reports (5 hours).

A special assignment schedule is issued to each student at the start of the semester. It informs him that, in addition to four routine written assignments (three business letters and one general piece of expository writing), he will have to submit eight inter-office memoranda (with specified attachments)

and one 2000-word (minimum) examination report. Work standards have been set up rigidly as organizational standards of the Research Institute. The quality stress requires that the student view himself not as a "student" but as a working engineer dealing with a job requirement.

The series of letter assignments constitute a sequential set of letter reports, functioning as progress statements in relation to the project job being undertaken in ME 432. In Engl 492, the Editorial Division is in effect leading the Junior Engineer through the stages of planning, writing, and editing of the report which is a terminal requirement in both courses. All correspondence is submitted typed, in duplicate to the Editorial Staff. Hence, copies of all correspondence go to the Project Engineer. The previously mentioned staff conferences permit co-operative control and direction to be exercised upon the student's handling and expository treatment of his project problem.

The letter assignments are spaced a week apart and require that the student (1) present a tentative statement of his project problem; (2) present a final statement of the project problem; (3) list the sources of information for the report; (4) define the subject, purpose, and scope of the report; (5) present a detailed outline of the report; (6) prepare an analysis of the introductory sections for the report; (7) write a first draft of the introduction; (8) submit the title page and table of contents. The final report is submitted at least two weeks prior to the end of the semester.

The Mechanical Laboratory Phase

ME 432 has been planned to train the student in (1) direct methods for formulating plans and procedures for specific engineering projects; (2) carrying out projects to satisfactory completion; (3) methods of evaluating the results of project developments; (4) methods of materials procurement and purchasing system requirements; (5) professional requirements for reporting.

Projects are formulated in the light of four realistically limiting factors: available facilities, student interests and capacities, the fulfillment of course requirements, and time. Project ideas have been developed from the suggestions of various technical departments or administrative offices of the school, from interested industrial organizations, from trade literature or professional journals, and frequently from the students themselves. Since the Research Institute plan goes into operation in the spring semester, the students are briefed by the Mechanical Engineering staff in the fall semester about the need for surveying project possibilities. The briefing includes an outlining of the Research Institute organizational plan, the co-operative aspects of the two courses, and the nature of objectives and requirements necessary to meet those objectives. Typical work projects which have been treated are these: (1) time and motion study of paper box manufacture; (2) the study of the electro-mechanical analogy as applied to a vibrational absorption unit; (3) the redesign and proposed method of manufacture of a Bostitch Wire Stitching Machine arm; (4) the study of re-inforced concrete beams compared with prestressed concrete beams; (5) the study and test of a steam wind tunnel.

In general, the ME 432 course has concentrated upon getting the Junior Engineer started on his problem and seeing that he keeps going in a reasonably promising direction. A carefully planned system of controls and checks has been effected to insure that the novice engineer will not get lost in a cloudy corridor. In a sense, the function of the Project Engineer is largely catalytic: he devises workable means for stimulating and orienting students continuously so that projects will operate at maximum efficiency. Supervision during laboratory hours and free discussion during the recitation hour (dealing with technical problems to be

solved) facilitate recognizable progress.

In addition, the student gains clarity throughout the project through the discipline of required regular submission of memoranda to the Project Engineer. After the initial selection of a project topic, each student is required to submit a statement which describes the investigation to be made, and an outline of the procedure to be used for the design, construction, and testing which would be undertaken as project requirements. The Project Engineer then discusses the statement with the student, attempting to modify, where necessary, the nature and scope of the project based upon practicability and student capacity or ability.

Once the project is acceptably formulated in a written statement, it receives a project number and title. At this point, the statement of intention is presented to the Director. Further scrutiny and evaluation results ultimately in the issuance of a contractual memorandum concerning the aim of the project and particular commitments. The Junior Engineer is then able to proceed in the direction and towards the end agreed upon.

Progress reports, initiated at this point and submitted at stipulated periodic intervals, permit control by the Project Engineer to be exercised further. All memoranda are approved only when inspection of work on the project tends to substantiate the statements of the memoranda. The work project itself and the final report are graded by the Project Engineer in terms of his requirements.

Conclusions

Three points-of-view are pertinent regarding the validity of the instructional method embodied in the "Research Institute" plan of instruction in report writing: those of the English staff, the mechanical engineering staff, and the students who have participated in the program. Conclusions are expressed in summary statements reflecting individual group emphases.

The English Staff

Conclusions relate to the values derived from the cooperative nature of the course:

(1) Student motivation is effective and immediate.

(2) Academic information becomes directly translated into "doing." No distortion of content occurs because "time-lag" is virtually non-existent.

(3) A sense of professional standards is carried to the student realistically.

(4) The student gains an integrated view of the report writing process. He can follow his report in action from earliest project planning stages to project completion.

(5) Inter-departmental collaboration permits the teaching staff to gain a broadening concept of technical reporting and consequently a release from academic provincialism.

The Mechanical Engineering Staff

These conclusions exist:

(1) The student gets the "feel" of actual engineering problems and the necessity for precisely stating those problems.

(2) The student learns functional procedural methods in approaching project analysis and development. He thus "previews" his later professional work.

(3) The student learns the need for realistic engineering *planning*.

(4) The student learns to use purchasing procedures and to estimate time required in materials procurement.

(5) The student learns to initiate and to develop effective experimental procedures and to carefully record *all* data associated with such procedures. He particularly learns to observe and to evaluate experimental data in accordance with scientific methodology applied to a job.

(6) The student learns the significance of organizational systems and procedures.

The Students

In April, 1953, a questionnaire, pointed to the evaluation of the combined course

program, was mailed to 122 graduates who, as senior mechanical engineering students, had been working members of the Research Institute at some time during the spring semesters of 1950, 1951, and 1952. Sixty-four of the questionnaires were returned, constituting a 52½% response. Replies were requested to be submitted anonymously if preferred. The following summary constitutes a grouping of the most pertinent remarks:

(1) 71.9% of those answering, in their present jobs, had to prepare internal memoranda or reports, either "regularly," "often," or "very often."

(2) 37.4% had to prepare external letters or reports, either "regularly," "often," or "very often."

(3) 89.1% of those replying believed that the combined course provided "actual value in terms of helping you meet job needs."

(4) Replying to a question about the values of each of the two courses, considered separately, 71.8% generally considered that Engl 492 had helped them meet job requirements for effective report organization and presentation. Most of the remaining 28.2% presented miscellaneous values received, somewhat linked to the majority conclusion. 65.8% considered that ME 432 had prepared them to effectively handle industrial project planning and development work. Most of the remaining 34.2% listed values somewhat related to this objective.

We are "sold" on this cooperative course plan. It has worked successfully for us and apparently for our graduates. Of course, this is not the only way to teach report writing. And it is likely not as good as some other ways. We simply recommend this program as a workable means to a good end.

A Public Relations Program for the Engineering Profession

By GERALD K. GILLAN

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Much has been said, and a little has been done, in recent years, about the universally recognized deficiency of the engineering profession commonly referred to as public relations. We admit to having poor public relations—for we continually talk of improving them. From the purely selfish point of view, a wisely conducted program of public relations is a good investment, for it leads ultimately to improved financial rewards for each member of the profession. More important to the truly professional minded person is the increased responsibility that comes with proper recognition, and the broadened opportunity to be of service to society.

Definitions of public relations are found to be numerous and varied. A noted brief definition is, "Public relations is being good and getting credit for it." Princeton's Professor Childs says, "Public relations is simply a name for those activities and relations of ours that are public and which have social significance." Wright and Christion [1] state, rather thoroughly, "Modern public relations is a *planned program* of *policies* and *conduct* that will build *public confidence* and increase *public understanding*."

The latter definition should appeal to the orderly minds of engineers. It is the basic thesis of this paper that a planned program of public relations is essential. The question that now presents itself is who shall do the planning and who the execution of the plan? Certainly it is evident that individual efforts, no matter how sincere, can not accomplish the task of establishing proper policies for the profession or proper conduct for each member of the profession. It seems evident to the writer that a modern public relations program must be planned and conducted by a unity organization of engineers, and that only such a unified action can hope to be truly successful. How critically important it is that unity of the profession be accomplished as soon as possible! Without it, the best efforts of segmental groups toward better public relations will continue to be largely vitiated by internal wrangling and almost child-like squabbling.

[1] "Public Relations in Management," Wright and Christion, McGraw-Hill, 1949.

Various Publics

Before proceeding further, perhaps it would be helpful to consider the nature of the "publics" with which the engineering profession wishes to establish and maintain good relations. It may come as a surprise to a few readers that there is not merely one big all-encompassing "public," but many "publics." Among the various publics the engineering profession must consider are:

1. Prospective students of engineering.
2. Parents of prospective students.
3. Teachers of prospective students.
4. Students in engineering schools.
5. Parents of engineering students.
6. Engineering school faculties.

7. Employers of engineers.
8. Employees of engineers.
9. Sub-professional engineering societies.
10. Technical engineering societies.
11. Professional engineering societies.
12. International engineering societies.
13. Foreign engineering societies.
14. Governmental agencies, local, state, national.
16. Other professions.
17. The general public.

The preceding list is not complete, but it may indicate the scope of the proposed program which will improve relations with so many varied publics.

It seems obvious that many of the publics must be contacted, not directly *by* a professional-unity organization, but *through* state and local representatives of a national (or inter-national) unity group. This conclusion certainly suggests the validity of recent arguments favoring a unity organization which is integrated from top to bottom at the local, state, and national levels.

The foundations of good public relations already exist in the engineering profession. The profession has existed for many years and has maintained an excellence of performance, a high standard of ethical conduct, and an encouraging growth of educational background that should make us all proud to be known as professional engineers. We know the profession is good. Getting credit for it is the problem.

It is not intended that any reader suppose that a high-powered press-agent is the answer to our needs. Public relations as a professional field is still recovering from the bad taste in the mouth left by many an irresponsible press-agent. The real instruments of public relations are *people*. Naturally, *people* as individuals can help or hinder. It follows that enlightenment of the individual member of the engineering profession, emphasizing his critical place in the planned program, is essential to the execution of a modern public relations program.

Long-Range Continuity Necessary

It is contended that planning a program of policies and conduct must be undertaken at a national level. Such a plan would be long-range and should reach lower levels not by osmosis but by a direct and easy route. It is not enough to send the word down the line once, to be forgotten when a new set of officers take over. A continual planned program must be formulated and executed. Launching the thing will require prior education and acceptance of key groups, at all levels. But long-range continuity must be maintained.

At this point, delegation at the state and local levels becomes essential. Group efforts and individual efforts must be directed and coordinated. Information must be readily passed down the line to keep local groups and individuals on the right track. Information on group and individual activities must move up the line so the guiding agency can keep in touch with progress and action at the lower levels.

Continual re-evaluation will be required. Aims and activities may change, or emphasis may be shifted from one to another. Operation of the plan is a terrifically important function. It must be in the hands of leaders who devotedly seek to improve the profession. Their ideas and ideals must correspond identically with those of the unified profession.

This plan would be no small thing. As a matter of fact, it borders on the monumental. How better could the engineering profession accomplish its goals than to seek the advice and guidance of professional public relations men? Let us retain an outstanding public relations firm to formulate a plan and aid in its execution and advise on its long-range

maintenance. Theirs is a young profession, but it is a recognized profession. How can our consciences rest if we fail to recognize them—especially when we stand to gain so very much.

This paper has a very simple purpose. It presents a course of thought and action which, if followed with reasonable faithfulness, should result in public relations that will be beneficial to the entire engineering profession and to the individual engineer as well. Men in engineering education are both members of the profession who will benefit and members of one of the most important "publics." They can be leaders in a modern public-relations program, or they can sit in their ivory towers and let others do it.

The Role of Graphics in Engineering Education*

By FRANK A. HEACOCK

Professor of Graphics, Princeton University

The purpose of this paper is to show the value and importance of graphics as an essential part of engineering education. The scope of the subject is broad enough to include not only the basic graphics courses in engineering drawing and descriptive geometry, but also the advanced graphics courses and other courses in the engineering curriculum that may be taught most effectively when graphic methods are employed. To understand and appreciate the educational value of graphics, we must appraise its objectives and realize the significant benefits that the engineering student derives from a well-rounded program of graphics instruction.

Graphics is both an art and a science. Considered as an art, the most popular form of graphics is engineering drawing, which has become the universal method of recording and communicating information in the engineering profession. Our industrial success is due in large measure to efficient planning on the drawing board. The more complex the production problem, the more urgent is the need for effective drawings to show the workman exactly what is required. As future progress in industry and technology will depend more than ever upon better working drawings, the drawing teacher today accepts the responsibility of giving engineering students the right kind of drawing instruction, so that the engineer of tomorrow will have the best working knowledge and drafting ability to plan future developments.

* Presented at ASEE Annual Meeting, University of Florida, June 1953.

The widespread usefulness of engineering drawing and its importance as a vital factor in industry overshadow its other educational functions. When properly taught engineering drawing does more for the student than develop drafting skill. It is the freshman's first professional course and it trains his mind as well as his hand and eye. While he is learning to make drawings that conform to accepted standards of drafting practice, the student acquires the ability to observe intensely, to visualize and think constructively in three dimensions, and to express his ideas by means of technical sketches. The development of correct thinking habits in relation to the planning, drafting, and interpretation of drawings and technical sketches is an important objective in the teaching of engineering drawing.

Sound Structure of Logical Reasoning

The science of graphics is introduced to the student in descriptive geometry, which provides graphic solutions for a wide range of three-dimensional problems involving form, position, direction, size, and geometric relationships. The transition from engineering drawing to descriptive geometry is a natural one, because both are based upon the same system of representation, orthographic projection. On this foundation descriptive geometry builds a sound structure of logical reasoning, established facts, and realtistic planning which culminates in an accurate solution on the drawing board. It puts into practice the engineer's method of thinking each problem through to a successful conclusion. It

trains the student to analyze a situation step-by-step, to organize his thoughts and direct them toward a definite objective. It exercises the imagination and it promotes the growth of the power of visualization. Descriptive geometry provides an excellent introduction to the study of graphics as an analytical tool.

An important feature of descriptive geometry is the direction of sight, the choice of a strategic point of view from which the problem may be seen to best advantage. Thus a line may appear as a point or a plane may show edgewise as a line in order to reveal true distances or relationships. The new facts discovered at each viewpoint build up the mental picture until it becomes a complete realization. In the analysis of problems by descriptive geometry methods the student learns how to size up a situation from any desired angle. The nimble, mental shift from one point of view to another makes the mind supple and stimulates the imagination. It gives the student a confident sense of direction when dealing with complex problems in our world of three dimensions. It orients his thinking, makes him resourceful, and develops good judgment in the selection of methods of solution.

In engineering education it is the responsibility of the graphics teacher to help the student develop a graphic mind, which is an asset of great value to the student while he is in college and after he enters his profession. Let us consider the graphic mind to determine what it is, how it works, and what we should do to develop it more effectively. It will be helpful to analyze the learning process and show how the graphic approach makes it easier for students to understand the theory involved in the difficult courses in the engineering curriculum.

Visual Aids to Learning

Educators agree that the eye is the open door to the mind. Students acquire many forms of knowledge more rapidly from pictures and demonstrations than from the words they read in textbooks or hear in lectures. Therefore visual aids to learning are popular in all branches of education. Most students are picture-minded and they prefer textbooks that are full of clarifying illustrations. A good picture is worth a thousand words because it tells its story at a glance. In engineering textbooks, however, pictorial illustrations are not always adequate. When the subject to be pictured is complicated, and particularly when its interior construction must be shown, two or more related orthographic views are necessary to convey the full meaning. Or the text discussion may require a different kind of illustration, such as a graph, diagram, or contour map. If the student has actually drawn similar graphic representations, he can interpret these illustrations quickly and with complete understanding. Personal experience on the drawing board with the various graphic methods is the minimum requirement for a graphic mind.

The engineering student devotes a large part of his first two years in college to the study of mathematics, chemistry and physics. These basic courses provide a background of fundamental principles that are essential to all engineers. Such courses are usually taught by faculty members who have no engineering experience and there is a tendency toward the abstract approach. As most engineers dislike abstractions, the student who is developing a graphic mind has an advantage in his own concrete approach to learning, even where no graphs are employed in text or lectures. Engineering drawing has sharpened his perception by requiring him to visualize the form, proportions, size, position, and function of physical objects. Then his mental vision has been deepened and made more adaptable by the analysis of geometric relationships in the study of descriptive geometry. This rewarding experience helps him to develop a keener insight, which he can apply to his stud-

ies to gain a firm grasp of the fundamental principles of mathematics and science.

In the development of engineering education a group of mechanics courses has become the backbone of the curriculum. Engineers must study statics, strength of materials, dynamics, and fluid mechanics to gain a working knowledge of their fundamental concepts. In this setting we can describe the graphic mind and show how it attacks engineering problems. It is a versatile type of intellect that is constantly aware of the graphic nature of things and instinctively pictures ideas in terms of geometric figures.

In the study of statics, for example, we have the basic concept of force which has the properties of magnitude, direction, and position. The mind pictures a force as a vector, a straight line with an arrowhead on it. When drawn to scale the length of the vector represents the magnitude of the force. The direction of the vector is made parallel to the line of action of the force, and the arrowhead shows which way the force acts. If several forces act at a common point, the vectors that represent them are drawn to scale in consecutive order and direction to form a closed polygon called a vector diagram. The closing vector which completes the diagram gives the magnitude and direction of a force that will hold all the other forces in equilibrium, a force equal and opposite to their resultant. If the forces involved do not lie in the same plane, two orthographic views of the vector diagram are necessary. In such cases the methods of descriptive geometry are used to determine three unknown forces which act at a common point with a known force, for a system that is in equilibrium. Graphic statics provides a well developed procedure of graphic analysis for accurately determining in one continuous operation the stresses, or internal forces, in all members of framed structures. Graphic statics deals with bodies at rest, but the vector principle is also a powerful tool for solving problems involving motion. In kinematics, for example, vectors are indispensable for representing displacement, velocity, and acceleration, which form a solid base for the study of all mechanisms. Each course in the mechanics group offers abundant opportunities for the application of graphic methods. The solution of mechanics problems by means of vectors and related diagrams clarifies the basic relationships and gives the student a better understanding of every factor involved.

Creative Ability

Engineering colleges are expected to develop a program for the training of engineers with ability to do creative work in the field of engineering design. Creative ability calls for originality, resourcefulness, ingenuity, and a constructive imagination. These essential habits of thought can be developed by a progressive program of instruction in graphics. The constructive thinking habits established by graphics courses at freshman level form a sound foundation for continued development of creative mental vision. This may be furthered by requiring the student to make frequent use of graphic methods in subsequent engineering courses. Facility in devising and applying graphic procedures wherever they can be employed to advantage is a necessary skill in all branches of engineering. In advanced courses a series of functional sketches provides the essential framework for the progressive development of ideas in projects designed to promote creative thinking. By clarifying relationships and by revealing possibilities for further development, each sketch gives a better grasp of the problem and becomes a springboard for accelerated progress. Instead of learning how to do specific things in a limited area, the student acquires the ability to solve new problems in unusual situations. Thus the project method, reinforced by a full utilization of graphic

aids, offers most promise in college training for the creative practical phases of engineering design.

As education and research are closely related, each helps the other, particularly at the graduate level. Teachers of engineering drawing and descriptive geometry can render a valuable service by acting as advisers to graduate students who are working on thesis projects and by assisting colleagues who are engaged in research. This arrangement facilitates the graphic analysis and interpretation of experimental data. Actual experience in setting up research problems and solving them by graphic methods leads to the discovery of important unsolved problems that challenge our best efforts. The versatility of the graphic approach has been demonstrated in recent research projects. Professor A. S. Levens at the University of California has applied graphic analysis to the successful development of a greatly improved artificial leg for veteran amputees. And at Columbia University Professor H. W. Vreeland is using descriptive geometry methods in the accurate control of radium dosage in cancer therapy. These significant achievements challenge the graphics teacher to devote his talents to research projects in science and engineering.

The future of graphics is of interest to all of us. How will engineering drawing and descriptive geometry be taught twenty years from now to meet the changing needs of engineering education? It is a safe prediction that these courses will widen their scope in order to keep pace with the expanding pattern of graphic applications in industry, science and technology. To make the best possible use of available teaching time the problems in engineering drawing should be consolidated to eliminate repetition and duplication of effort. Each problem may well combine many new characteristics of instructional value to the student. In order to simplify drawings and make them easier to read with full understanding, we shall probably adopt an abbreviated method of drafting and dimensioning, featuring the omission of unnecessary details, which will save valuable time on the drawing board. Drafting standards will be revised in keeping with the more efficient drafting methods required by industry.

Technical Sketching

Courses in engineering drawing will devote more time and greater emphasis to technical sketching. The student should acquire facility in making functional sketches in various technical applications. The drawing project method will offer the future engineer actual practice in developing a real problem which will awaken new interests and stimulate the motivation that spells success in engineering. Affording opportunities for creative thinking, each project would require a systematic approach to the best solution of the problem through the medium of the idea sketch and progressive development sketches. Good judgment will be reflected in the final design sketch and its companion working drawing. Thus the drawing project would give the student the right start in his college training for the design function of engineering.

What future changes are likely in the teaching of descriptive geometry? This applied science provides the necessary background for the study of graphics as an analytical tool. Future courses in descriptive geometry may well condense their treatment of intersections, warped surfaces, and axonometry in order to save at least a third of the teaching time which should be devoted to problems in advanced graphics and an introduction to graphic analysis. This new material should be closely coordinated with fundamental problems in the various mechanics courses and in specialized fields of engineering. Many technical investigations dealing with forces, motion, velocity, and acceleration are based to a large extent upon

the use of vectors and related geometric constructions. Wherever the problems involve three dimensions the methods of descriptive geometry can be applied to advantage. An introduction to graphic methods of computation, such as nomographs and graphic calculus, would give the student greater confidence in these useful tools when he encounters them in subsequent studies. Applications of graphic principles to the interpretation of experimental data should be included in the new material of analytical graphics. The illuminating experience of step-by-step graphic analysis will give the student tangible verification of fundamental concepts and require orderly, effective reasoning. This wider scope of instruction will enhance the value of graphics in the education of future engineers.

Many interesting articles have been published in recent technical journals describing new applications of graphics to the solution of technical problems in various fields of engineering, science, business and industry. This widespread awakening of interest in graphic methods offers a challenge to the teachers of graphics. I would like to urge my colleagues to explore the fertile fields of advanced graphics and to engage in graphics research projects of a fundamental nature. This fruitful personal experience will enrich their teaching of the graphics courses and strengthen the role of graphics in engineering education.

Effective Counseling for Engineering Freshmen

By ROBERT L. RITTER

Assistant Professor, Dept. of Engineering Drawing, Marquette University

Marquette University

(A comparative Analysis showing the negative and positive correlation between High School Rank, College Grade Point averages and American Council on Education Raw Score Ranks.)

One estimate made concerning the ratio of Engineering freshmen to Engineering graduates suggests that by 1960 approximately seventy thousand freshmen will be needed to supply approximately one-half this amount of graduates. At first glance we might question the enormous gap between the two groups. However, those of us whose assignments quite closely parallel the activities of our freshmen can readily visualize the many unforseen situations appearing with more frequency among our student bodies; thus accounting for the 2:1 ratio between freshman registration and senior graduation respectively. Most of us can visualize quite clearly the reasons for reductions among freshman personnel. We can see, but are we able to understand? As absentism infects our routine, as dropouts occur with more rapidity, and as academic censure seemingly increases with activity among the remaining, ours is a dissatisfied and frustrated lot. Whether our interest lies in Administration or supervision or carries us into the classroom the depreciation in the numbers of freshmen as they proceed toward senior status affects us severely and challenges our very existence as educators. We educate, yet those we would teach are mysterious in their actions and puzzling in reactions to what we would claim as normal situations.

Although we possess at present many standardized forms of human measurement, we are unable to plot and account for human behavior as we would mechanical or electrical energy. Counseling can be dangerous and disasterous at times if performed without skill and an analysis determined without reason. Therefore, that which would be proposed here as a possible solution to a seemingly unsolvable problem must be accepted with the reservation that human behavior cannot be couunted for with infallible accuracy.

Useful Measuring Devices

On the other hand, it would seem unwise to proceed year after year totally unaware of the usefulness of existing educational measuring devices and the tremendous possibilities they afford insofar as Administrative and Counseling functions are concerned.

We are apt to judge the performance of our students as a group rather than as individuals. Assuming, as most of us do, that our freshman registration represents the upper third of our high school enrollment, we measure their progress on the same basis. This hypothesis would suggest that all high schools are of equal size, equal staff, possess the same facilities and offer identical extra curricular activities. If this represented the actual situation we might then assume the upper third of our high school enrollment, which accounts for a high percentage of our

freshmen, to perform with nearly equal results.

We know that many of our freshmen come to us from small schools with poor facilities and staffed unfortunately, but all too frequently, with tired, inefficient and uninterested personnel. Compare the background of these students with those from an entirely opposite situation. Can you in all fairness expect students affected by different environments to possess the same immediate potential? In an analysis of this sort, we are reminded of the students coming to us from the sub-standard scholastic environment mentioned previously who, in many cases, perform with academic zeal. In other words, with careful consideration given to all of these situations, are we justified in our appointment and classification of freshmen according to high school rank?

The first hypothesis to be set down here states that we are not. On the other hand, it would be unwise to seemingly criticize a procedure without proposing a new method to correct the inaccuracies and inefficiencies of the old. As a contribution in this direction it will be shown here how the American Council on Education raw score ranks can be used effectively as Administrative and Counseling aids.

The graphical analysis shown in the illustrations indicate what Marquette University's College of Engineering has done and is still doing to bring to its freshmen effective counseling. We have felt this need much more since the High School graduate has once more become the nucleus of our educational program. More time must be spent and more of our effort expended on those students offering the greatest Engineering potential.

The first analysis was made with a relatively small freshman group numbering 160 students. Although this particular class was larger, test results were not available for all of the students.

Each of the 160 students had been given the American Council on Education test, and his relative raw score rank determined. The A.C.E. raw score ranks were purposely arranged in ascending order as shown in Fig. 1A with student No. 1 representing the lowest and student No. 160 the highest rank.

At the end of each successive quarter, for the following six quarters, a record of each student's academic rank was established and recorded on the graph directly above his A.C.E. raw score rank (Fig. 1B). The purpose of this procedure was to show justification for belief in a correlation between A.C.E. raw score rank and grade point averages. The graphical analysis shown in Figure 1B represents a grade point average over a period of six quarters for each of the 160 students. Graphically, a very high positive correlation is evident between the A.C.E. raw score ranks and grade point averages. The mathematical correlation between grade point averages and the corresponding A.C.E. raw score ranks shown is (.7).

These results indicated the possibility of much success in correlating A.C.E. test results relative to future student counseling.

Correlation

In addition to showing the evidence of an existing correlation between the A.C.E. raw score ranks and college grade point averages the necessity was apparent for proving the hypothesis of the absence of correlation between high school rank and college grades.

Each student's previous high school rank was registered graphically with relation to his college academic average (Fig. 1C). Because of the normally accepted theory relative to a high positive correlation between these two, it seems probable that the graphical solution shown here in Fig. 1C might serve as an illustration indicating the lack of confidence to be placed in the determination of college potential relative to high school performance.

To permit these results to function as

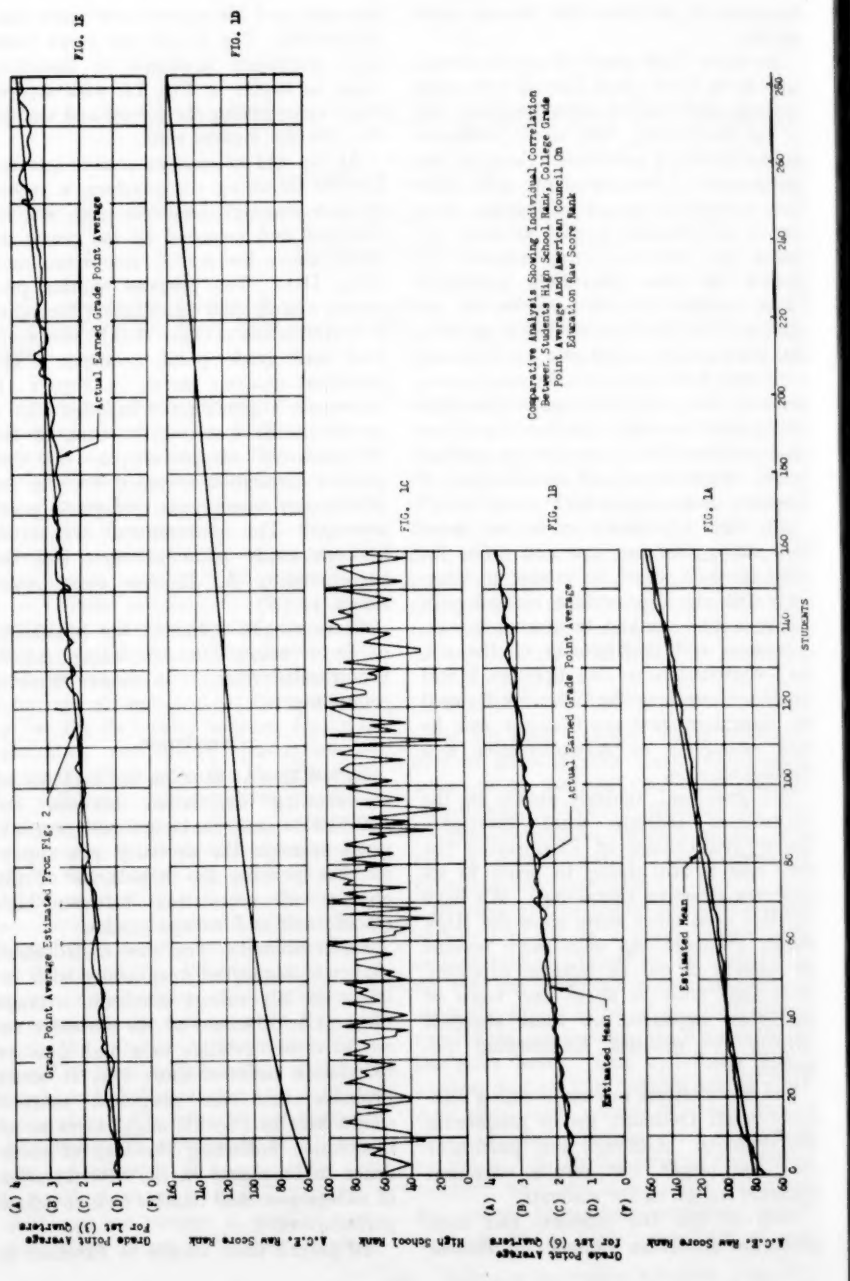


FIG. 1E
FIG. 1D
FIG. 1C
FIG. 1B
FIG. 1A
Comparative Analysis Showing Individual Correlation
Between Students High School Rank, College Grade
Point Average And American Council On
Education Raw Score Rank
Grade Point Average Estimated From Fig. 2
Actual Earned Grade Point Average
Estimated Mean
Grade Point Average for 1st (J) quarters
A.C.E. Raw Score Rank
High School Rank
Grade Point Average for 1st (6) Quarters
STUDENTS

an administrative and counseling aid, it was necessary to transfer the graphical solutions into a more positive and functional form. To promote this end, a straight line grade point average was drawn to exclude high and low variations (Fig. 1B). This can be justified on the basis that variations away from this line might be due to a few unreliable A.C.E. test scores or outside influences affecting a student's academic performance.

The straight line representing the mean grade point averages for all cases permitted the determination of an approximate grade point average for each A.C.E. raw score rank. The results of this analysis are being used on an exploratory basis for counseling new applicants and currently enrolled freshmen. The graph shown in Fig. II, having been derived from the foregoing investigation, is now being used for these purposes.

The analysis of Fig. (2) permits a more concentrated counseling effort by separating the group into three distinct divisions, namely: (1) Students from 60 to 99 A.C.E. raw score rank who are to be accepted with the understanding that their status is tentatively probationary. Immediate use of University guidance facilities is recommended for this group. (2) Students from 100 to 119 A.C.E. raw score rank who might actually be designated as the border line group where individual academic rank could very well go in either direction. University guidance facilities are recommended for this group sometime during the first quarter. (3) Students from 120 to 160 A.C.E. raw score rank. Academic censure among this third group will usually be due to outside influences and not lack of ability. Full use of University guidance facilities is recommended for this third group only in extreme cases of academic censure.

Counseling Program

The three divisions as described here should, of course, be used for preliminary investigation and will prove most desirable in laying the ground work for an effective counseling program. However, the appearance of a student in any one of the three classifications must not be treated as a basis for all future counseling until the student's academic performance together with the administration of all available guidance and testing material has shown the classification to be correct.

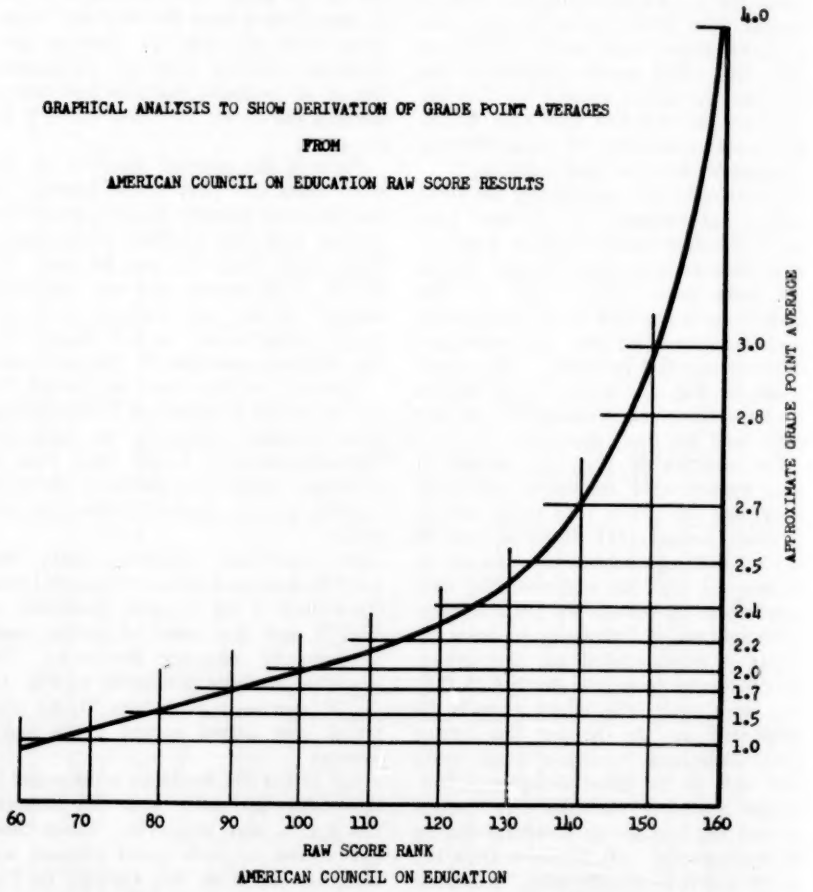
Perhaps the greatest good to be derived from this part of the analysis is the follow-up possible concerning an able student with low academic achievement. Much counseling time has, in many instances, been wasted and not justifiable because of the low academic potential of the counselee and the lack of supporting evidence available to the counselor.

More of our time must be allotted for the derivation of causes of failure among those students possessing the tools for academic success. At the same time, it is a poor policy and indeed a waste of time to push a student beyond his capacity.

An additional follow-up study was made to determine the correlation between the results of the research illustrated in Fig. 2 and the potential grade point averages of entering freshmen. The graphical analysis illustrated in Fig. 1E A.C.E. raw score rank been 97, his estimated and actual earned grade point average.

All of the 284 freshmen represented in this follow-up study were administered the A.C.E. test, Fig. 1D. From these raw scores, a grade point average was assigned based on the analysis in Fig. (2). As an example: Had a student's A.C.E. raw score rang been 97, his estimated grade point average selected from the chart (Fig. 2), would have been approximately 1.9 (C −). In a like manner an estimated grade point average was made for each of the 284 students (Fig. 1E). For three quarters an accurate record was made of each student's academic progress. The graphical analysis shown in Fig. 1E indicates the mean earned

grade point average for each student and its comparison with the estimated average made prior to his participation in the Engineering curricula. The graphical analysis indicates the existence of a high correlation between the two.



60-99 — These students should be accepted with understanding that status is tentatively probationary. Immediate use of University Guidance Center facilities is recommended for this group.

100-119 — This is the border line group where academic rank could go in either direction. Recommend use of University Guidance Center facilities for these students sometime during first quarter.

120-160 — Students in this group should do well. Academic censure in most cases will be due to outside influences and not to lack of ability. Recommend use of Guidance Center facilities in case of academic censure.

FIG. 2

Conclusion

The predetermination of a student's approximate scholastic attainment before his active participation in an educational program, if used wisely by proper administrative personnel, can be beneficial to both the advisor and advisee. However, care must be exercised to eliminate classification of a student's ability in a particular field before performance has shown the analysis to be correct.

The research as presented here is now being carried on with a larger group under most favorable testing conditions to verify, it is hoped, previous results obtained and for the alteration, if necessary, of any data tending to affect the final analysis shown in Fig. 2.

It is felt that the results of this study, as they are being used, will afford greater vision toward the promotion of the academic welfare of each individual engineering student as is now evident by the appearance of new possibilities of research and will in time provide an atmosphere of greater understanding between administrative and student personnel.

Can Technical Institute Graduates Succeed in Engineering Colleges?

By LEO F. SMITH

Dean of Instruction, Rochester Institute of Technology

and

LAURENCE LIPSETT, *Director Counseling Center, Rochester Institute of Technology*

The primary objective of a technical institute is to prepare graduates for a technical job or a cluster of such jobs. A certain percentage of graduates of technical institutes, however, develop an interest in pursuing their education toward the bachelor's degree.

There is very little information available regarding the success of technical institute graduates in entering and completing post-institute education programs. It was the purpose of this study to determine the amount of academic transfer credit received by graduates of technical programs at the Rochester Institute of Technology and to find out the subsequent success of those graduates in the institutions to which they transferred.

It should be pointed out that the R.I.T. programs under consideration were definitely terminal in nature and were not designed to obtain transfer credit.

Procedure

The Department Heads of the ten day-school departments at the Rochester Institute of Technology were asked to submit the names of a sampling of graduates during the last ten years who were believed to have completed programs in four-year institutions. The transcripts of these students were then obtained from the institutions to which they had transferred. There was no direct contact with the students themselves.

Of the total group of students followed up, 31 were graduates of the following three curricula: Electrical Technology, Mechanical Technology and Industrial Chemistry. This sample of 31 students did not include all of the R.I.T. graduates of these three departments who might have transferred to other institutions, but in general these students were among the more able scholastically.

Twenty-two of the 31 students had completed technical institute programs which were full-time during the first school year (38 weeks). During the second and third years the students alternated at ten-week intervals between school and cooperative employment in industry. In other words, these students had completed two full years of academic work in a three-year period. The other nine students in the sample had attended the Institute prior to 1946 when the entire three-year program had been on the cooperative basis. These latter students had, therefore, completed somewhat less than two academic years of classroom work.

Results

1. All 31 students in the sample obtained bachelor's degrees.

2. Twenty-three of the 31 students received degrees in engineering; the remainder received degrees in the physical sciences. (All of the engineering cur-

riculums represented in this study are E.C.P.D. accredited.)

3. The average amount of transfer credit for the 31 students was 61 semester hours, and the range was from 27 to 94 semester hours. (Credits recorded in terms of quarter hours were converted to semester hours.)

4. The grade-point average for the 31 students was 2.82, and the range was from 1.74 to 3.68 (Where A = 4, B = 3, etc.)

5. The amount of transfer credit received and the grade-point averages earned by the graduates of other R.I.T. departments, who transferred to four-year institutions, were at least as high as those received by the graduates of the Electrical Technology, Mechanical Technology and Industrial Chemistry curriculums.

Conclusions

This study is based upon only a sample of the graduates of three technological curriculums at the Rochester Institute of Technology who continued for post-institute education. Although the number of graduates included in the study is not large, the official transcripts of the institutions to which these students transferred make clear two major points:

1. That some engineering colleges grant substantial amounts of transfer credit to qualified technical institute graduates.

2. That this transfer credit is justified in terms of the subsequent success of those transfer students in the engineering colleges.

ANNUAL MEETING

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Pennsylvania State University
State College, Pa.

Arts and Sciences for Engineers

By WILLIAM WHIPPLE, JR., *Colonel, CE, U. S. Army*

Modern business and modern government obviously require the broadest possible understanding of economics, political institutions, labor and public relations, and international affairs. Our country has lost the institutional and fiscal rigidity that once allowed industry to operate within fixed rules on a laissez-faire basis; and almost any business must now have a constant eye to its relationships with government, with labor, and with the public. Competitive strategy of big business in the modern world requires an understanding of national political economics as well as the traditional play of the market. In addition to this, the Federal government, for better or for worse, is engaged in many large scale engineering and scientific enterprises which require the broadest possible national outlook for their proper execution. Finally, within the last six years, both private firms and governmental agencies have become involved in an unprecedented series of engineering and technical activities abroad, bringing larger numbers of Americans into intimate contact with the social and economic affairs, the law and the people of other countries all over the world. If the broader purposes of such missions are to be fulfilled, our representatives abroad must have imagination and insight, in addition to the required technical abilities.

At the same time that engineers and industrialists are being thrown increasingly into situations where they need the training of politicians, economists and diplomats, the technical requirements of the professions are becoming more complex. The proliferation of new developments in the sciences and in chemical and electrical engineering calls for intensified training in the chosen field rather than allowing for breadth of education. The same tendency, though not quite so marked, exists in civil and mechanical engineering. Engineering Societies' statistical analyses of financial compensation have added strongly to such tendencies by showing that recent graduates with Master's degrees in engineering or science have materially higher starting salaries and maintain their advantage thereafter, and that those with Ph.D.'s are still more highly paid. These statistics, while they serve the useful purpose of outlining critical needs for highly trained men, must accentuate the trend toward compartmentalizing the engineer and the scientist into restricted fields, unless the curriculum of graduate study can be broadened in some way.

A marked difference in intellectual viewpoint exists between engineers and liberal arts students, and also between their respective faculties. It is striking to an outsider to note what differences in attitude characterize faculties in (say) engineering, agriculture and political science, and each has its counterpart in the alumni world in which the rest of us live. Chief engineers and attorneys, for example, are apt to have entirely different basic business concepts, although the really qualified executive will often include both. On matters pertaining to governmental affairs, characteristic attitudes and persistent misunderstandings between groups can repeatedly be traced to the academic source. In addition to divergences of viewpoint, there exist important hiatuses in the development of knowledge which have not been covered

adequately by either group. It is widely realized that the very highest concepts of education and of national interest require an intellectual integration of the diverse points of view in the world of today.

Admirable in Concept

The inculcation of a broad philosophical background for leadership through the liberal arts approach is admirable in concept, its main defect being that it does not leave the graduate in an advantageous position from which to enter any particular line of work. The very high proportion of lawyers who attain high policy making positions in Government, for example, does not stem nearly so much from the direct value of the knowledge acquired in the university as from the availability of a career pattern leading to the acquisition of influence, diversity of knowledge, and the habit of solving problems quickly. The finest intellectual background and the soundest of conclusions on important matters may be largely wasted unless they can be applied to affect the lives of other men. In democratic America, leaders are chosen from many elements of society, and it would be fallacious to compartmentalize university education today on any assumption that the engineering graduates will remain in technical fields.

In any enterprise involving applications of engineering science the vast majority of the major problems confronting senior executives require knowledge other than technical for their solution. These aspects become more important and take more of the individual's time the higher he ascends in his career pattern. Prominent among these matters are personnel management, legal aspects, public relations, labor relations, economic and financial relationships, governmental affairs, techniques of negotiating and techniques of self-expression. Mistakes in these fields are as costly as technical mistakes, and abilities in these fields, or at least a number of them, usually characterize the successful executive. It is on account of the engineer's deficiencies in these nontechnical fields that lawyers and bankers often take over the management of enterprises of a technical nature, successfully correcting various deficiencies and overcoming their own lack of engineering knowledge by the simple technique of accepting specialized advice from the proper specialists. The young man who has spent five to seven years acquiring advanced technical education remains very deficient in the background essential to an executive.

In a few colleges with the strength of their convictions, the basic engineering course has been broadened materially. Time for such extra subjects can only be found by leaving out applications and concentrating on basic engineering and mathematics. From a long-term point of view, this is sound; as many current engineering applications, impressive as they now appear, will no doubt be as obsolete in twenty years as the technology of 1933 is today. However, from the point of view of a company or agency looking for new men to do an urgent job, which is the most favorable situation for new graduates, some degree of familiarity with modern technology is a great advantage. In this competitive world, any great degree of broadening the basic engineering curriculum will be extremely difficult for the great majority of colleges to achieve.

Curiously enough, in many high schools the objective of a broad intellectual approach appears to be pursued more enthusiastically than it is in colleges; and immature children are often asked to write a quick theme on such topics as the United States' attitude toward Soviet participation in the United Nations. At such levels of education, interest-stimulating techniques without much basis of factual analysis are all that is practicable. Such indoctrination offers a real advantage, provided the child is preserved from the delusion that a decision may be arrived at in such matters after listening to a brief indoctrination by the teacher

and hastily scanning one or two references.

However, it is at college levels, and afterwards, in the years of early maturity when selectivity begins to determine the leaders of the future, that a sound intellectual broadening of the base must be obtained. After success in a career has been achieved, it is much more difficult. There is little opportunity or time to supplement the education of the lawyer who has ascended the bench or has been elected to Congress, of the industrial magnate who enters a policy-making governmental position, or the scientist who becomes head of a great laboratory. Not only has the individual already passed his most formative years, but his time has become too valuable; there are pressing demands upon him which he cannot deny. Many such individuals have through their own inspired efforts or through fortuitous circumstance of changing positions, especially in wartime, acquired the invaluable broadening of outlook. But why should such an important matter be left so much to chance? Our educational processes should provide more ways for the intellectual integration of thought through university training, instead of concentrating higher education on specialization, while leaving a wide gap between the various cultural and the engineering approaches to intellectual development.

As an aside, the terms "liberal arts" and "arts and sciences" as denoting the non-technical aspect of education are generally considered roughly equivalent. In our modern age, in which the onrush of science and technology threatens to outmode philosophy, it is well to hold fast to the value of literature, history and the ethical concepts upon which our civilization is based. But the term "liberal arts" when considered as excluding engineering and, ostensibly at least, science, sounds like an "ivory tower" concept to the practical man. Surely, prominent among the points of view which should be comprehended by a broad cultural approach for instruction of future leaders, the scientific and engineering attitudes and concepts should be prominent. The awkward term "arts and sciences" may or may not be more comprehensive of what the modern scholar should know, but it is certainly more comprehensive of what the modern statesman should know.

Tendency Toward Specialization

The progress of science many generations since has passed the point where any man could be successfully educated as a scientist without specialization. For the future, science will be increasingly specialized, such broad subdivisions as chemistry having in turn been subdivided already into fields in each of which progress is so great that a man must narrow his field in order to master the subject. What the public broadly considers as scientists includes categories of nuclear physicists, chemists, astronomers, and many others, who have widely differing fields. Engineering is subject to the same tendency although to a lesser degree. There are wide opportunities for civil and industrial engineers who have a sufficiently wide technical education and background to integrate the activities of a variety of specialists in the fields of mechanical, electrical and chemical engineering, as well as the simpler structural, foundations and materials techniques which they must apply directly. The basic engineering degree in many cases still constitutes a relatively broad education in basic science and in a few cases has been further broadened considerably into non-technical fields, as mentioned earlier, although it has not been possible even in those few cases to approximate the education of "engineering generalists."

A Master's degree in engineering may include certain non-engineering matters such as engineering economics and business law, but is still primarily technical. The doctorate is more apt to point towards specialization; and does not satisfy the need of integration of technical with over-all intellectual concepts. Moreover,

a doctorate in engineering probably represents a longer period of technical education than is either required or desirable for one who desires executive positions in construction or industrial activities. A young man with basic engineering education is more apt to broaden his viewpoint through variegated business experience than through two or three more years of graduate engineering education, valuable though the latter may be for purposes of research or other special technical activities.

In attempting to broaden engineering education, it must not be forgotten that for the future engineer or business man, the first and indispensable requirement is the basic technical background to obtain and to hold a job. Despite recent recognition of the value of a general education on the part of a few top industrialists, there is no use in diluting a technical education to a degree that will jeopardize this primary mission. Most of the engineering graduates in the majority of colleges and universities are going to pursue careers such that their technical proficiency will remain not only initially, but permanently the most important part of their background from the point of view of remuneration and advancement. The problem is to consider how, within these limitations, the objectives we have been discussing can best be achieved. The basic undergraduate training for engineers can only be broadened at the expense of curtailing or eliminating technical subjects. As indicated previously, the engineering applications rather than basic studies should be curtailed. A considerable change in this direction can be made without adverse effect upon immediate job prospects if the student will get a job during the summer, in some practical engineering work. The value of such an internship to the prospective employer is very great. Time made available in this way should allow the instruction of young engineers in a limited number of non-technical subjects, giving them an intellectual background which, while not immediately of value in the first permanent employment, makes them much better prospects for wider leadership in the future.

The extent to which liberal arts subjects should be introduced into an engineering curriculum depends upon the objective. Undergraduates with the greater possibilities of future leadership should be given more non-technical work. Public speaking and good composition and technical writing should be developed to a greater degree incidental to other courses. Literature, philosophy, public affairs and American history courses should be included if possible. A seminar course in the senior year might well be organized jointly with public administration majors, to consider government participation in engineering enterprises. There is ample material which would be stimulating to both groups of students.

In order to make room for such training, some subjects must be combined or reduced in scope, such as water supply, sewage and highways, heating, air conditioning, refrigeration, advanced communication circuits and industrial electronics. Some of this type background can be covered during summer employment or field trips, and in general such subjects can be more readily acquired later when needed than can the more basic engineering subjects.

Change in Educational Approach

Such a change in educational approach will require cooperation from business and governmental employers. In the first place, the employer must accept such graduates with a minimum of theoretical training in technological applications, relying on later job training and experience to give proficiency in productive techniques. In view of the long-term advantages of the system, it is believed this limitation will be accepted, as applied to graduates from colleges of good general reputation, who are being recruited for future assistant executives rather than technical specialists. Most

businesses would just as soon do their own specific job training along their own lines and would willingly accept a summer of previous practical experience in place of a few academic engineering courses, many of which may not be directly applicable to the work at hand.

In addition to summer jobs of an engineering nature for students, arrangements should be made, where possible, for a full year of employment before a graduate year. Such an arrangement will be more difficult to effect, on account of fear by the employer that the well-qualified graduate, after his year on the job and year of post graduate training, would then transfer to some other company rather than return. However, such an interval of work prior to completing graduate work is extremely beneficial, because it gives the subject matter a concrete reality in the mind of the student and a motivating interest that only rarely will be developed from a purely academic approach.

A further advance in effectiveness of education in preparing for leadership could be achieved if the individual could return later, after five to ten years of experience, for a full year, primarily non-technical in nature. Courses would include economics, public affairs, international relations, business administration and public speaking. The selection for such a course would be made after the individual had established satisfactory and stable job tenure and after he was known to be executive material, but not yet a key executive. The award of an academic degree would be desirable though not essential.

Only the interest of top management and a strongly supported system of scholarships could institute such a course on a wide scale. By this period in his life, the individual will ordinarily have started a family but will not yet have achieved financial security or savings sufficient to undertake another year of education at his own expense. The temptation is for management to agree to an additional year only if it relates directly to techniques of the immediately foreseeable future, whereas the more general background would undoubtedly pay higher dividends in the long run, especially from the point of view of public interest.

Conclusion

Such a system as above described, with four years broadened undergraduate engineering study, a year of actual work, and a year of graduate engineering study, followed by a sixth year of more general nature some years later, would be of great advantage in training broader gauge leaders and executives for business and government. It would capitalize heavily on the lost opportunities which result from the intellectual hiatus between the technical and the liberal arts point of view, and from the misunderstandings between operating elements and fiscal or legal advisors of many organizations, and between the engineering and the broader economic and public relations requirements of business. It would provide material for executive appointments in government, making less frequent the harrowing necessity of choosing between the practical man whose ideas and philosophy are closely bound to his own experience and the broad thinker and analyst whose basically valid ideas cannot be implemented within the bounds of practicality.

CANDID COMMENTS

An Open Letter to Industrial Executives

By R. D. LANDON

Dean, College of Engineering, The University of Akron

Mr. U. R. Entrepreneur, President
Expando Corporation

Dear Sir,

During the last few years in particular, we have appreciated the increased interest which your company has demonstrated in the engineering graduates from this college. We have welcomed your interviewers to our campus, supplied them with convenient facilities and furnished them with complete information on students in which they have been interested. We have been gratified that your company has selected a number of our graduates for technical employment in your organization. We have gained satisfaction from your reports that our graduates are measuring up to their responsibilities. We trust your interest will continue and that we shall always be able to produce graduates which will meet your rigorous specifications for young engineering talent.

There is no assurance, however, that we can continue to produce graduates of this same caliber. We, along with so many other colleges which are forced to operate on a relatively fixed income, are not presently in a financial position to compete with industry for the services of outstanding graduates. Some graduates whose first interest is in teaching are willing to accept a small differential in salary but they will not accept an essentially lower standard of living, nor should they be expected to, in order to follow the teaching profession. It is most difficult, therefore, for many engineering colleges to recruit the proper caliber of young teachers who should become the core of our faculties in future years.

Another serious difficulty in building a competent and stable staff stems from the practice of some companies which are offering every possible financial inducement for our most promising young instructors to leave their educational work and accept industrial employment. As a matter of record, your company has just offered one of our outstanding young instructors a salary as high as we can afford to offer a full professor. Consequently, many engineering colleges are now faced with the dual difficulty of *recruiting and holding* promising young teachers.

We fully realize that industry needs the best young talent it can recruit and we know that the competition between some companies, and even between divisions of the same company, to secure the services of promising engineering graduates is very keen. Since, in this competition, the colleges are being forced out as active competitors, is it not evident that industry will be the ultimate loser? How can competent graduates be produced if there is not a high degree of competency with stability in our college faculties and how can the colleges insure this competency and stability if they are in an unfavorable position to bid on the open market? These are questions which we must ask industry to help us answer since they cannot be answered with the resources available on many college campuses today.

We have watched with keen interest the development of your scholarship program which is making it financially possible for more and more highly qualified high school graduates to prepare themselves for technical employment in industry. To use your terminology, the scheduling of selected basic material to the engineering schools is improving but the processing is becoming more difficult as our manpower resources are being siphoned off.

Can you afford the risk of not insuring the quality of instruction your young engineering employees should receive? Is it possible, therefore, that you would be able to provide financial assistance to the promising young *instructor* as well as to the highly qualified young *student*?

We are calling this problem to your attention now because we believe you will appreciate that it is ultimately yours as well as ours. Unintentionally, industry helped to create it and now we need the benefit of your experienced judgment which, together with your material aid, could be major factors in the solution.

We trust that your interest will promote a cooperative effort, the results of which will benefit both engineering education and industry.

Very truly yours,

A. N. EDUCATOR, *Dean*

Teaching Tips

Leadership Training in the Laboratory

By WALTER E. ROGERS

Associate Professor of Electrical Engineering, University of Washington

If I were trying to promote a wider readership of this article, I should perhaps entitle it: "How to get out of the laboratory at 5 o'clock." In fact I was answering this very question recently, when I realized that deliberate and planned training in leadership and organization was not the wide spread practice that I had assumed it was. I grew up with this system about 20 years ago in the mechanical engineering laboratories at the University of California, so I cannot claim to be more than an advocate of the system. Of these undergraduate days, few details are now distinct, but I remember the leading and planning of experiments very clearly, and I expect that almost everyone who has experieneed this teaching method at the receiving end was similarly impressed.

The idea is a very simple one. Warned in advance, one member of a laboratory party is made completely responsible for the conduct of an experiment. He is required to list the equipment which will be needed, including such details as the ranges of the instruments. He makes his own abbreviated step by step procedure from a study of the syllabus sheet or the general requirements outlined by the instructor to the class, and facilitates the assembly of the apparatus by preparing circuit diagrams. He assigns the various tasks of the day to the other members of his party. He may delegate such details as seem fitting, such as instrument calibrations, preliminary warm-ups, roughing out the data sheets, and providing the carbon paper. He retains responsibility for the dispatch and the efficiency of the conduct of the experiment. Required to submit and discuss his plans with the instructor in advance of the laboratory period, the leader frequently finds ways to suggest additional lines of investigation somewhat beyond the call of duty as outlined on the syllabus sheet.

The right and proper objection to all this, is that each and every student should plan every experiment he performs, understanding its goal rather thoroughly before he arrives at the laboratory. This ideal is as difficult to attain as is the corresponding utopia in which every student studies his lesson every day. On the other hand, rotating this responsibility from man to man throughout the course seems to encourage planning on the part of the rest of the party. For one thing, the students are keenly aware of the possibility that the leader may not show up. Further, they soon find out that the best planning is done when the entire party gets together and all contribute ideas.

It is a pleasure, pardonable I think, to observe the ingenious punishment which can be conceived by a group of students for the lackadaisical leader. Recently one of these arrived at the appointed hour, just before the laboratory period, having read the syllabus, but without having prepared written plans

and diagrams. According to the rules, no power could be applied to the circuits until the leader had met the requirements. While this boy was thus occupied, his partners, having also planned in advance, wired up the equipment in a weird and wonderful way. Most of the changes required in going from one test to another were to be accomplished by an elaborate array of switches rather than by rewiring. This made an imposing circuit to check.

The errant leader, meanwhile, had drawn his circuits in the conventional manner doing one thing at a time. After approving his belated plans, we walked together to his test section, and thinking I saw a gleam in the eyes of one of his partners, I asked the leader to explain to me just what this patch board was intended to accomplish, and how he proposed to operate it. In particular, which switch was he going to open if unexpected difficulties arose? Of course, he had little idea of what was being done to him, and his partners were of no help at all. About half an hour later he had figured things out, and after explaining them to me, handled the rest of the afternoon's proceedings rather well.

Getting the students' cooperation on this is easy. It may be set up simply as a rule of the course, or it may be sold the first day with a practical story from industry. I describe the economics problem behind the crews of riggers, electricians, machinists, and the like which are required to set up and test a piece of machinery. One can also point out that if the engineer directing the test discovers the next day that he doesn't have all the data he needs, he may find that the machine is now in a box car and half way to the customer.

From the educational standpoint, I think this sort of thing carries what could be a more or less routine laboratory assignment a little closer to the project method of teaching that we hear so much about, but sometimes find difficult to apply in courses which we teach only infrequently.

Getting back to the 5 o'clock question, it is really surprising what a group of students can accomplish in a 3 or 4 hour period when they know what they are going to do, and are working under a time limit.

A Comprehensive Testing Method for Advanced Courses

By W. W. TURNER

Assistant Professor of Electrical Engineering, University of Maine

A difficulty with many types of examinations given in engineering courses is that they test the ability of the student to apply theory to a particular problem solution without determining whether or not he understands the physical significance of the results obtained or if he can draw general conclusions from particular results. Since these last two qualifications are important in the practice of engineering it seems desirable to at least get an indication of the extent to which they have been developed in the individual student and in so doing to impress on him their importance. The testing method herein described provides a means of measuring these abilities and at the same time demonstrates the effect of varying a particular system parameter without requiring each student to repeatedly perform the same calculation using different numerical values. It also shows the advantage of a team approach to a problem as well as giving the student an opportunity to work independently on a fairly involved problem.

The technique outlined below has been successfully used by the author in a second semester senior course in feedback control, but should lend itself to other courses in which system performance is the major consideration.

1. Design a problem in which the effect of varying certain parameters is to be determined and assign each student particular values of parameters for which he is to determine the system response. In feedback control the problem might take the form of finding the changes in resonant frequency and allowable gain for a specified maximum ratio of output to input as the time constant of an RC integrating network is varied.

2. Encourage the students to compare their methods and results in order to discover for themselves the general effect of the variations and to see if their results are reasonable when compared with those for other parameter values.

3. A few days before the examination is to be given collect the solutions and tabulate the results, inserting additional values, some of which are incorrect.

4. Return the solutions with corrections and comments not only on the final answer but also on the methods and techniques employed.

5. Ask questions on the examination which can be answered only if the student understands the methods he has used and has been diligent in making his comparisons with the other solutions. Typical questions might be (a) analyze the tabulated data to determine if any results seem inconsistent and explain why they appear to be out of line, or (b) discuss the effect of changing some other parameters in the system. In the feedback control problem already cited one might ask the student to determine the effect of changing the resistance in series with a generator field winding. (This simply changes one of the other time constants of the system and therefore its effect is predictable from the data already obtained.)

Since the validity of the conclusions is to be emphasized rather than speed, the number of questions should be kept to a minimum in order that the student can give careful thought to each one. Grading of this type of examination might be accomplished by assigning a minimum passing grade for the satisfactory completion of the problem and letting the answers to the examination questions determine the A, B, and C students.

Use of this method with small groups of less than ten has indicated that the students like it because the emphasis is on quality of the work and not on speed. Resulting grades appear to be more representative of engineering ability than those obtained from some other types of examinations. There would seem to be no obstacle to applying this testing procedure to larger groups except that in general it probably demands more of the instructor's time to do a careful job of grading than would an examination requiring only numerical answers.

Personalizing Teacher Student Relations by the Use of Student Pictures

Professors who find it difficult to learn the names of their students when they are each semester confronted by one hundred or more new faces may find some help in a method that Professor Lawson has successfully used to solve this problem. Several years ago at the University of Florida he decided to do something about his own situation and started taking group pictures of each of his classes. He then had these pictures enlarged, cut out the individual pictures,

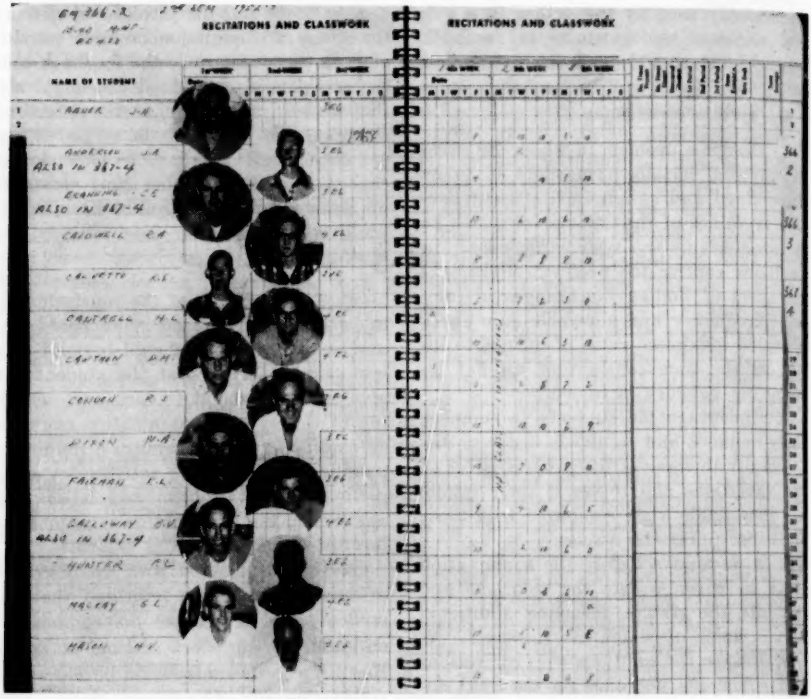

FIG. 1. Individual student pictures in roll book.

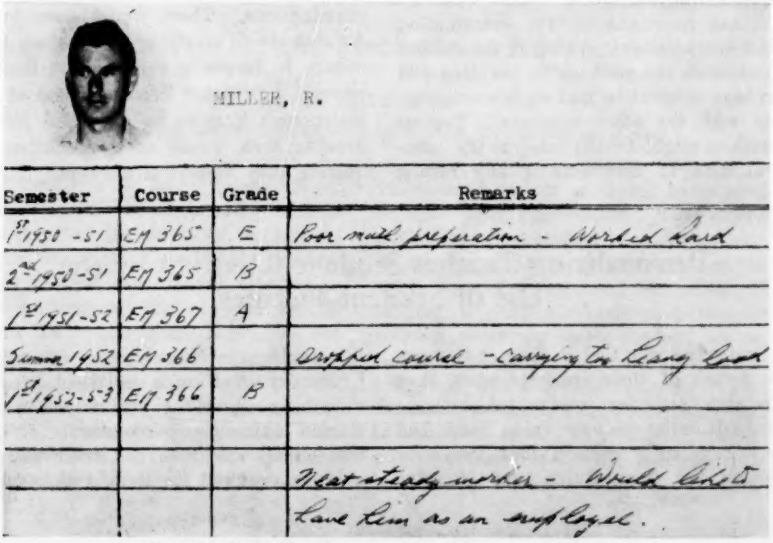
MILLER, R.
Semester
Course
Grade
Remarks
1st 1950-51 Eng 365 E Poor mark preparation - Worked hard
2nd 1950-51 Eng 365 B
1st 1951-52 Eng 367 A
Summ. 1952 Eng 366 Dropped course - Carrying too many hours
1st 1952-53 Eng 366 B
Neat steady worker - Would like to have him as an employee.

FIG. 2. Individual permanent student record card.

and attached them opposite each name in his roll book as shown in Figure 1.

He found that this method helped in getting to know his students quickly. However, there were disadvantages to the group pictures because of absences or latecomers to the course. This semester Professor Lawson set up lights and a 35 mm camera in his office and used the last ten minutes of the first day of each class to take individual pictures of each student. Twenty-five pictures can be taken easily in five minutes or less. With the camera at about four feet from the subject, contact prints can be used, and at least twenty-five pictures can be printed on each sheet of paper. The cost is negligible. The camera can be left set up to get any absentees or adds.

Professor Lawson makes further use of these pictures by keeping them in a permanent card record. He has duplicate prints made of the pictures and puts one copy on a mimeographed card as shown in Figure 2.

This card file has proved invaluable when called upon for recommendations for students whom the professor hasn't seen for several years and whose face he cannot recall.

Dartmouth's "Shop" Course

By J. J. ERMENC, *Professor of Mechanical Engineering* and J. A. BROWNING, *Assistant Prof. of Mechanical Engineering*

The molding of the Shop Course at Dartmouth was influenced by those thought-streams in engineering education which suggest that

1) The conventional shop course in engineering colleges is a manual training course, and, in toto, represents a sub-minimal achievement;
2) Tests or experiments can be performed in college shops which can be as intellectually significant as those performed in those laboratories liaisoned with such courses as Fluid Mechanics or Thermodynamics.

The course, started in 1949, is given during a five-week period immediately preceding the fall semester of the fourth year of the five year curriculum. The week consists of five eight-hour days.

About two weeks are used for the usual shop work and welding. (Pattern-making, foundry practice, forging and the like, are dealt with "sotto voce." The general picture of these aspects of shop are presented via movies followed by an occasional lecturer who may speak on some scientific aspect of the subject.) Some simple but ornamental piece is made in the shop to involve the use of the fundamental machine tools. A few days are allotted to the acquiring of sufficient skill to make butt and lap joints with both gas and electric welding. A fillip to the welding session is the tensile testing of student work.

The remaining three weeks of the term is used for the experimental or test work. Three days are devoted to each experiment, split more or less evenly between the gathering of data and the supervised writing of a formal report. The experiments or tests performed are concerned with:

1) The performance of a milling machine;
2) Metal-turning principles;
3) An introduction into the machineability of steels;
4) Spot welding principles.

The milling machine test relates power per volume rate of metal removed to

speed, feed, and depth of cut as well as the characteristics of the cutting tool and the material being cut.

By means of a Lando Autographic Dynamometer, the effect of lathe tool angles on cutting forces are easily determined as well as the power requirements for variations in speed, feed, depth of cut, and materials used.

The determination of the machineability of steels by a drill-penetration method attempts to correlate this factor with the physical properties of the steel.

The test using the spot welder is an investigation into the time variables of squeeze, weld, and hold, as well as weld pressure, current, materials, and surface oxides on the strength of welds.

The speed with which students finish their manual training varies considerably. This slack is taken up by the design and construction of some simple device. The most ambitious project has been the design and construction of a milling machine dynamometer. The usual product falls in the personal gimmick category.

There are excellent movies available on fundamental shop practices which are used and a visit is made to a nearby foundry and machine tool manufacturer.

The course in its experimental aspects provides an intellectual stimulus to the student as well as the instructor. It is a growing asset to the mechanical engineering curriculum.

THE T-SQUARE PAGE

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Graphics Conferences

By J. NORMAN ARNOLD

Associate Professor of General Engineering, Purdue University

Two conferences on "Graphics" which were held during the fall of 1953 carried forward the objectives of the Advanced Graphics Committee of the Drawing Division even though the conferences were sponsored by Midwestern universities and industries rather than by the Division.

One called an Engineering Institute on "Graphical Presentations" was held at the University of Wisconsin on October 6, 7, and 8. Those registered for the Institute included engineers employed in a variety of industries mostly from Wisconsin and Illinois.

The topics discussed during the three-day session included: General Methods for the Solution of Functions of Two or More Variables, Uses of Graphs, Conic Sections and Power Functions, Empirical Equations from Engineering Data, Analogue Computer Demonstration, Network Charts, The Graph Analogue, Graphical Calculus, Special Slide Rules, Alignment Charts.

The discussion leaders represented several University of Wisconsin departments and also included one representative each from Northwestern University, Purdue University, and Gerber Scientific Instrument Company.

A feature of the closing session of the conference was the presentation of particular problems to the discussion leaders for their comments and suggested methods of solution.

The second, or "Engineering Graphics Conference," was held at Purdue University on November 20. Engineers from Indiana and neighboring states as well as several college representatives attended.

The topics discussed included: Introduction to Graphics, Delineation, Analogous Representation, Problem Solutions, Computing Devices, and Reproduction Processes. The speakers on these topics were Purdue University staff members, with discussion by industrial representatives. The program was planned by a joint University-industry committee.

A feature of considerable interest was an Engineering Graphics Exhibit open to the public, and particularly convenient for students to see, throughout the week including the conference day.

Conferences like these provide an excellent opportunity for engineering drawing teachers to learn of developments in industry and for practicing engineers to become better acquainted with some graphical devices and methods. The acquaintanceship which is stimulated and the discussion of some problems of mutual concern are beneficial all round. It

seems possible that conferences like these might aid engineering drawing departments to meet the challenge of the times.

The Wisconsin conference was conducted by Professor Paul J. Grogan for the College of Engineering and University Extension Division.

The Purdue conference was sponsored by the Department of General Engineering in cooperation with the Division of Adult Education. Professor J. Howard Porsch served as chairman.

Proceedings have been published as a Purdue Engineering Extension Bulletin.

Teaching Positions Available

The following rules were adopted by the General Council of the ASEE:

The privilege of advertising for teaching positions is extended only to colleges and technical institutes which are either Active or Affiliate Institutional Members of the ASEE. Advertisements must be for positions available only. No advertisements will be accepted for an individual seeking a job.

Advertisements must be submitted not later than the first day of the month preceding the month of issue. Because of limited staff, the ASEE headquarters cannot maintain personnel files or supply detailed information about jobs. In replying to blind ads, address letters to American Society for Engineering Education, Northwestern University, Evanston, Illinois and give blind ad number. Information and rates for advertising in the Journal can be received by writing ASEE Headquarters. In order to conserve space and achieve uniformity, the privilege is reserved to rearrange advertisements.

INSTRUCTORS (2) IN MECHANICAL Engineering, to teach kienmatics, machine design and related subjects. Opportunities for sponsored research. Large university in Middle Atlantic region. MA–1.

INSTRUCTOR OR GRADUATE ASSISTant in petroleum production engineering beginning September 1954. Opportunity for graduate work toward M.S. degree. Apply to Petroleum Engineering Department, 105 State Hall, University of Pittsburgh, Pittsburgh 13, Pennsylvania.

ASSISTANT PROFESSORS (2) OF ELECtrical Engineering. University of North Dakota, Grand Forks, No. Dak. Duties: One man to teach electronic and communication courses, and one man to teach electrical power courses to undergraduate students. Appointments to begin in September 1954. An advanced degree plus some teaching or industrial experience preferred. Submit resume of education and experience to Head, Electrical Engineering Department.

INSTRUCTOR OR ASSISTANT PROFESsor of Electrical Engineering; M.S. desired with specialization in electronics; to teach communications, circuits, and radio wave propagation courses. Also, Instructor or Assistant Professor of Mechanical Engineering, M.S. desired with leanings toward heat power, heating, ventilating and air conditioning; or internal combustion engines. Positions available September 1954. Send application to President, South Dakota School of Mines and Technology, Rapid City, South Dakota.

ASSISTANT PROFESSOR OF MECHANIcal Engineering to teach machine design. Must be graduate of an accredited engineering college with some experience, and be familiar with stress analysis, materials and processes, ease of manufacture, maintenance and cost. Salary $4,000 to $5,000 per year for nine months. California. Permanent. J–2.

INSTRUCTOR IN MECHANICAL ENGINEERING. Recent graduate to teach courses in engineering drawing, mechanical engineering laboratory, etc., beginning September 1954. Also an instructor in physical metallurgy and metals processing. Opportunity for graduate study. Good pay and fringe benefits. Location: New England. J–1.

MECHANICAL ENGINEERING GRADUate up to 38, advanced degree preferred, to teach heat engines and related subjects. Salary and rank depend upon qualifications. New building and equipment. Start September 1, 1954. Apply to the Dean of the School of Engineering, University of Mississippi, University, Mississippi.

VIRGINIA POLYTECHNIC INSTITUTE. Instructor to teach Engineering Drawing and Descriptive Geometry beginning September 1954. Must be a graduate in a major engineering curriculum. Experience desirable, but not essential. Apply to Department of Graphics, Building 362, Blacksburg, Virginia.

INSTRUCTOR IN GENERAL ENGINeering, to teach engineering drawing, descriptive geometry and other subjects. Engineering degree required. Appointment to begin Sept. 1, 1954. For further information write R. P. Hoelscher, Room 200 Transportation Building, University of Illinois, Urbana, Illinois.

Minutes of Executive Board Meeting

A meeting of the Executive Board of the American Society for Engineering Education was held on April 9, 1954 at the Missouri School of Mines, Rolla, Missouri. Those present were: L. E. Grinter, *President;* W. L. Everitt, B. R. Teare, Jr., E. A. Walker, W. C. White, *Vice Presidents;* A. B. Bronwell, *Secretary;* G. W. Farnham, *Treasurer.*

Report of the Secretary

1. The Secretary reported that as a consequence of the YET Membership Campaign 400 of the 650 new members were in the ranks of instructor and assistant professor. The Executive Board requested that its appreciation for this successful undertaking be conveyed to the Chairman of YET.

2. The Secretary reported that the General Council had voted 47–0 in favor of adopting the Amendment to By-Law IV, relating to dues of individual members.

Quarterly Financial Report

The Quarterly Financial Report indicated that the deficit for the year may be of the order of $2,000 rather than $4,300 as budgeted.

Investment of Society Funds

The investment of Society funds was discussed. The Society has $69,300 in a checking account which does not draw interest. Of this amount $30,000 was a contribution by the Carnegie Corporation for the Humanistic-Social project, $5,600 is the balance of contributed funds for the project Evaluation of Engineering Education, and $6,000 is contributed funds for the Teaching Aids project. Thus, $41,600 of the cash account represents contributed money, held for special projects. Dean Dawson, Chairman of the Society's Committee on Financial Policy, recommended investment of $5,000 in a savings account and $10,000 in Series K United States bonds. Dean Dougherty, another member of the Committee, had suggested investment in 2½% coupon, negotiable federal bonds.

It was pointed out that some of the Savings and Loan corporations pay between 3% and 5% interest and that funds are insured up to $10,000 by the F.D.I.C. The Board suggested that $15,000 be transferred from the checking account to a savings account in a good conservative bank. It was further recommended that $10,000 be retained in the checking account and that the balance be invested in Savings and Loan Banks, the amount in any one bank not to exceed $10,000. The Secretary will correspond with Dean Dawson to get his views on this matter before proceeding further. Mr. Farnham will get information on Savings and Loan Associations.

Budget for 1954–55

A tentative budget for 1954–55 was presented for consideration. The Board recommended certain changes in budgeted expense and deferred adoption until the meeting in June.

The Board recommended appointment of a committee consisting of Deans Everitt and Teare to study Secretarial salaries.

Annual Meeting Plans

The Board discussed plans for the Annual Meeting. The Secretary and Assistant Secretary have held several meetings with the Local Committee at the University of Illinois. The plans are shaping up for an excellent meeting.

Summer School Financing

The Secretary pointed out that the Society has no provision for financial assistance to ASEE sponsored Summer Schools. They are permitted to charge a registration fee, but this places the financing on a precarious basis since the advance reservation is not known early enough to make definite plans. After consideration of this and other Summer School problems, the Board voted to set aside in future years a reserve of $1,000 to $2,000 to underwrite Summer School expenses. It was understood that the Divisions would endeavor to place Summer Schools on a self-financing basis, but the funds would be available in the event that a deficit occurred. It was also recommended that any excess of income over expense in Summer School operations be returned to the Society to be placed in the reserve pool.

Fall Meetings of ECAC–ECRC

The desirability of holding a Fall Meeting of ECAC–ECRC was discussed. Owing to the substantial proliferation of meetings and the increasing burden on the travel expense budgets of engineering colleges, the Executive Board recommended that ASEE should not hold a Fall Meeting, unless something should develop to specifically warrant it. The General Council meeting will be in conjunction with the ECPD meeting in Cincinnati on October 27, 1954.

Evaluation of Engineering Education

President Grinter reported that the Interim Report of the project Evaluation of Engineering Education had been completed by a small writing committee which met at Raleigh, N. C. This will be sent to all members of the Committee on Evaluation for their criticisms and approval. The next meeting of the entire Committee will be on Sunday preceding the Annual Meeting at the University of Illinois, unless the criticisms indicate need for a full Committee meeting before June. The Interim Report will be available to all those who register for the Annual Meeting and it will be published in the September 1954 issue of the JOURNAL.

The Executive Board recommended continuation of the Evaluation Committee as and *ad hoc* committee. After one year, a Final Report should be prepared, unless greater delay is necessitated by unforeseeable conditions.

President Grinter recommended that the Institutional Committees prepare a revision of their institutional reports in the light of the recommendations of the Interim Report. These would be prepared in sufficient quantity so that they can be bound and made available to engineering college libraries throughout the country.

The Tuesday morning General Session at the Annual Meeting will feature a talk by President Grinter on Evaluation followed by a panel discussion and discussion from the floor.

Resolution to ECPD and Engineering Foundation

The Executive Board voted to transmit the following resolution to ECPD and its constituent societies:

"The members of the Executive Board of ASEE wish to express to the constituent societies of ECPD their grateful appreciation for their financial contribution to the project Evaluation of Engineering Education. This project, which has had the active participation of over 1500 engineering educators throughout the country, has been one of the most thorough studies of engineering education ever undertaken. The project, which was made possible by the contributions of the constituent societies of ECPD and other organizations, has pointed the way to significant changes in engineering education to meet the needs of rapidly developing science and technology; it has engendered a spirit of challenging inquiry which will help to keep engineering education responsive to the needs of the profession."

The Executive Board also voted that a similar resolution be transmitted to the Engineering Foundation.

Investigation of Graduate Study

The proposal of the Graduate Studies Division to conduct a comprehensive investigation of curricular goals of graduate level education was discussed. Professor Christensen, Chairman of the Division, has invited a number of leading educators and administrators in graduate fields to attend the luncheon at which the proposal will be discussed. Several sources of possible funds for the project were considered. The Board recommended that the Graduate Studies Division formulate a specific proposal and prepare a statement of its budget needs so that the Executive Board can assist in the solicitation of funds.

Humanistic-Social Project

Vice President White reported that conferences between Dr. Burdell and Dr. Gullette had been successful in shaping up the initial stages of the Humanistic-Social Research project and that field visits would be made soon. The project will be officially launched in June at the Annual Meeting. An Interim Report will be prepared for June 1955. A printed announcement of the project will be mailed to deans and officers of the Society.

Industrial Fellowships

The Secretary presented a proposal for ASEE administration of a Fellowship program to be financed by contributions from industry. This proposal was developed as a consequence of inquiries which have come to members of the Board as to whether or not ASEE could handle such Fellowships. A number of industries would like to contribute to higher education, but they have no satisfactory formula for making contributions without showing partiality. A Fellowship program, administered by ASEE, in which industrial financed Fellowships would be awarded to recipients selected by ASEE, would provide a means whereby industry could contribute to higher education on an impartial basis.

It was pointed out that industrially financed Fellowships would not contribute substantially to the funds available for engineering colleges, since the cost of graduate level education usually exceeds the amount of income received from the student. The Board recommended that this plan be studied by ECAC.

EJC Proposals on Individual Membership and Regional Membership

Proposals of EJC to develop a plan of Individual Membership, as well as a plan of Regional Memberships, was discussed. Considerable concern was expressed over the proposal to provide Individual Memberships in EJC. The primary function of EJC is to have committees of leading engineers study national problems bearing upon engineering. This type of operation can be severely impeded by an organization containing a large number of individual members, since there would inevitably arise the demand that the individual members be given a vote on important committee proposals. If individual members are denied the privilege of participation, their membership would be meaningless.

No specific action was taken on the proposed amendments to the EJC Constitution, but the Board expressed the viewpoint that the plan for individual membership in EJC does not seem to have been developed to the point where the Society can feel confident that it will make a significant contribution. This matter will be referred to the General Council for consideration in June.

EUSEC Representative

The Secretary reported that ECPD has voted to appoint all three delegates to the EUSEC Conference on Engineering Education, to be held in Switzerland in the fall of 1954, and pay their travel expenses. It was pointed out that ASEE can make a significant contribution to this conference in presenting the Report of its Committee on Evaluation of Engineering Education. The ECPD has invited Col. L. F. Grant (President of ECPD), T. Saville, and L. E. Grinter to serve as representatives.

An industrial man will also be appointed to the commission provided that his company pays the travel expenses.

Printing Costs

The Treasurer presented a preliminary study of the costs of printing the JOURNAL OF ENGINEERING EDUCATION and *Proceedings*, using the offset printing process. This study indicates a possible saving of several thousand dollars per year on the *Yearbook*, but no substantial savings on individual issues of the JOURNAL. It was pointed out that Lancaster Press now provides a substantial service in handling the Society mailing, in storing and selling back issues of the *Proceedings*, and in performing other useful services to the Society. The Treasurer will try to complete the study and present a report at the June meeting of the Executive Board and General Council.

Associate Institutional Memberships

The Executive Board voted Associate Institutional Membership to the following companies:

McGraw Electric Company
Portland Cement Association
Witco Chemical Company
American Society of Agricultural Engineers
Borg-Warner

Applications of the Association of American Railroads and the Ontario Professional Engineers were held pending further inquiry.

Code of Ethics and Oath

A proposal from Dean Trezise to establish in engineering colleges a practice of administering an oath to engineering students, similar to the Hippocratic oath for medical students, was discussed. The opinion was expressed that there is a trend in modern times away from ritualistic ceremonies and it was questioned as to whether the students would regard this in the same solemn sense that doctors regard the Hippocratic oath. No action was taken.

The Executive Board expressed the opinion that the Canons of Ethics might be used to better advantage in all engineering colleges and recommended that Dean Freund consider the possibility of urging the deans of engineering colleges to post these on bulletin boards and give reprints to all students either at the freshman or senior level. The suggestion was also made that ECPD consider the possibility of mailing the Canons of Ethics without charge to all engineering freshmen or seniors.

ASEE Branch at Purdue University

A petition from Purdue University for an ASEE Branch was approved by the Executive Board.

Associate Membership Drive

The Executive Board voted to send Mr. Jesse McKeon, Chairman of the ASEE Committee on Associate Institutional Membership, an expression of appreciation for the excellent job of handling the Society's Associate Institutional Membership Drive and congratulations on having passed the goal of 100 Institutional Members.

ECAC Salary Study

Consideration was given to the advisability of ECAC conducting a study of faculty salaries. There have been numerous requests for this information and individual schools are beginning to send out questionnaires to collect these data. It was estimated that the cost of such a salary study would be of the order of $1,000. This was referred to ECAC for further consideration.

Request for Division of Nomography

A request for a Division of Nomography in the ASEE was rejected, with the recommendation that the matter be referred to the Division of Engineering Drawing.

Respectfully submitted,
ARTHUR BRONWELL,
Secretary

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
Allegheny	University of Pittsburgh	April 30–May 1, 1954	W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May 15, 1954	R. G. Owens, Illinois Institute of Technology
*Kansas-Nebraska	University of Nebraska	Fall, 1954	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz University of Michigan
Middle Atlantic	Lafayette College	May 8, 1954	H. M. Jenkins, Swarthmore College
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Catholic University	May 8, 1954	C. H. Walther, George Washington University
New England	Massachusets Institute of Technology	Oct. 9, 1954	E. R. McKee, University of Vermont
North Midwest	Michigan College of M. and T.	Oct. 8–9, 1954	C. J. Pratt, Michigan College of M. and T.
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	California Institute of Technology	Dec. 28–29, 1954	B. M. Green, Stanford University
Rocky Mountain	University of Utah	May 14–15, 1954	A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Cornell University	Oct. 22–23, 1954	N. A. Christensen, Cornell University

Members of the Society are welcome at all Section Meetings

*** No Date Set.**

New Members

ANDERSON, A. MELCHER, Manager of Technical Education, General Electric Company, Room 300, Building 23, 1 River Road, Schenectady, N. Y. M. M. Boring, D. S. Roberts.

APPLETON, GLENN R., Instructor in Mechanical Engineering, South Dakota State College, Brookings, South Dakota. D. H. Madsen, L. L. Amidon.

ARMENTROUT, PETER C., Engineering Training Supervisor, Boeing Airplane Company, Seattle, Washington. V. M. Ganzer, H. E. Wessman.

ARNOLD, ROBERT G., Instructor in Engineering Drawing, University of Wyoming, Laramie, Wyo. A. J. McGaw, F. L. Spenner.

BARBERII, EFRAIN E., Director of Escuela de Petroleos, Universidad del Zulia, Maracaibo, Edo. Zulia.-Venezuela.-S. A. J. C. Klotz, R. L. Langenheim.

BARTON, JAMES R., Research Engineer in Civil Engineering, Colorado A. & M. College, Fort Collins, Colo. W. E. Code, M. E. Bender, Jr.

BATKE, THEODORE L., Instructor in Chemical Engineering, University of Massachusetts, Amherst, Mass. E. E. Lindsey, I. S. Pflug.

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BLACKWELL, WILLIAM A., Assistant Professor of Electrical Engineering, Texas Technological College, Lubbock, Texas. C. V. Bullen, Margaret Atkinson.

BOHL, ROBERT W., Assistant Professor of Metallurgical Engineering, University of Illinois, Urbana, Ill. A. C. Forsyth, H. H. Hilton.

BOYD, T. A., Research Consultant, Research Laboratories Division, General Motors Corporation, Detroit, Michigan. K. A. Meade, R. L. McWilliams.

BRAND, GLENN E., Assistant Professor of Chemical Engineering, Missouri School of Mines, Rolla, Mo. W. T. Schrenk, F. H. Conrad.

BRENBERGER, LLOYD P., Head of Industrial Engineering, University of Dayton, Dayton, Ohio. A. J. Morgan, B. M. Schmidt.

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SCHWEHR, FREDERICK E., Instructor in Drawing and Descriptive Geometry, University of Wisconsin, Madison, Wisconsin. H. B. Doke, F. O. Leidel.

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TETLEY, WILFRED H., Associate Professor of Mechanics, United States Military Academy, West Point, N. Y. Archie Higdon, F. S. Roop, Jr.

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TRUMAN, JOHN C., Assistant Professor of Aeronautical Engineering, USAF Institute of Technology, Dayton, Ohio. G. R. Graetzer, H. B. Kepler.

TUCKER, WILLIAM H., Associate Professor of Chemical Engineering, Purdue University, Lafayette, Ind. F. L. Serviss, R. Schuhmann, Jr.

TURNEY, JOHN J., Instructor in Mechanical Engineering, University of Connecticut, Storrs, Conn. H. C. Tobey, E. R. Stephan.

VANDEGRIFT, LOUIS E., Professor of Civil Engineering, Ohio State University, Columbus, Ohio. K. W. Coseus, G. E. Large.

WEAR, ROBERT J., Head of Airplane Department, Academy of Aeronautics, LaGuardia Airport Station, New York, N. Y. Raymond Troell, B. J. Buc.

WENNAGEL, NORMAN GUSTAVE, Instructor in Engineering, State University of New York Maritime College, Fort Schuyler, N. Y. J. Foody, A. O. Porter.

WISEMAN, HARRY A. B., Research Associate in Engineering, Pennsylvania State University, State College, Pa. G. J. Hasslacher, J. W. Breneman.

WITTMER, FRANKLIN B., Associate Professor of Chemistry, Michigan College of Mining and Technology, Houghton, Mich. H. B. Anderson, Earl Roberts.

645 new members elected this year

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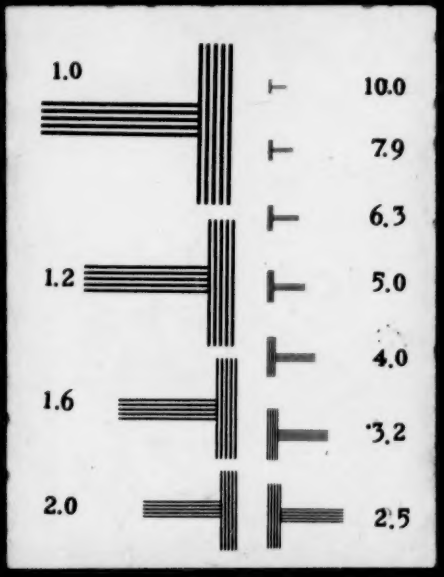
RESOLUTION CHART



100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and $100/20 = 5$.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and $7.9 \times 5 = 39.5$ lines per millimeter recorded satisfactorily. $10.0 \times 5 = 50$ lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.